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APPROXIMATE FORMULÆ FOR BEAM-COLUMNS.

By INSTRUCTOR COMMANDER R. O. WHITING, M.A., R.N. (RET.).

THE fact that the deflection of a strut, having initial curvature and an axial load P, is very nearly equal to the original deflection multiplied by $\frac{1}{1-\frac{P}{P_e}}$, (this is exactly true for an initial sine curve deformation), does not appear to have been applied consistently to the derivation of approximate formulæ for the bending moments in beam-columns. It will be convenient to write K for the ratio $\frac{P}{P_e}$, where P_e is the Euler failing load and is equal to $\frac{\pi^2 E I}{l^2}$

It is hoped that the following remarks may be of

Fig. 1.

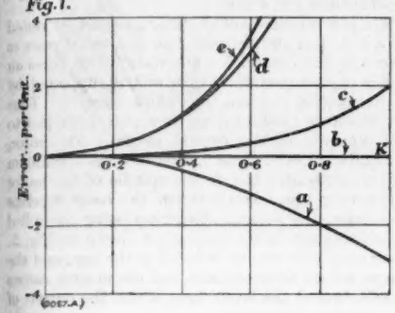
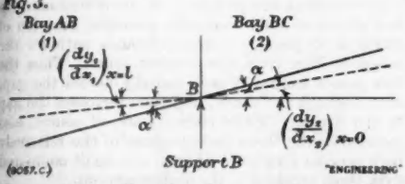


Fig. 3.



interest in showing that this approximation leads to a simple, accurate, and correlated series of expressions for the bending moment in the case of simple loading; also that it provides an easy graphical solution where that is suitable and convenient; and that the same assumption might be reasonably supposed to apply in the case of continuous beam-columns to produce a simple formula for the solution of that problem.

Simple Loading.—Let δ and δ_0 be the deflections, and M and M_0 the bending moments, with and without P respectively. It then follows, on the assumption that $\delta = \delta_0 \frac{1}{1-K}$, that

$$M = M_0 + P\delta = M_0\left(1 + \frac{\delta_0}{M_0} P \frac{1}{1-K}\right).$$

Whence, by substituting the appropriate value of $\frac{\delta_0}{M_0}$, and also writing $\frac{P_e}{\pi^2}$ for $\frac{E I}{l^2}$, this reduces to the simple form

$$\frac{M_{max.}}{M_0} = 1 + a\,B. \quad . \quad . \quad (1)$$

where a is a simple whole number, and

$$B = \frac{\pi^2}{48}\frac{P}{P_e - P} = 0{\cdot}2056\frac{K}{1-K}.$$

For example, in the case of a freely-supported strut having a uniformly distributed lateral load, the maximum deflection without end thrust is $\frac{5\,w\,l^4}{384\,E\,I}$, and the maximum bending moment is $\frac{w\,l^2}{8}$, whence

$$\frac{\delta_0}{M_0} = \frac{5l^2}{48\,E\,I} = \frac{5\pi^2}{48\,P_e},$$

and

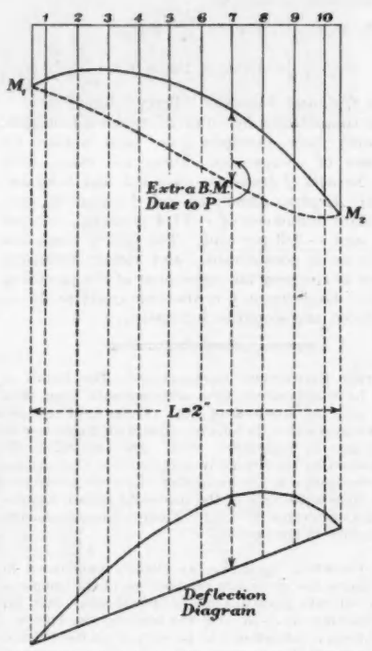
$$\frac{M}{M_0} = 1 + \frac{5\pi^2}{48\,P_e} P \frac{1}{1-K} = 1 + 5\,B.$$

If we put $\theta = \frac{\pi}{2}\sqrt{\frac{P}{P_e}}$, then $B = \frac{\frac{\theta^2}{12}}{1-\frac{4}{\pi^2}\theta^2}$, in which form we may see the similarity to formulæ derived by approximating for $\sec\theta$ in the exact solutions.

Table I shows the exact expression for $\frac{M_{max.}}{M_0}$ for various basic types of lateral loading as derived from the orthodox differential equations, and arranged to give them in a form comparable with each other and with the appoximate formulæ in the adjacent column. The numerical sequence of these latter formulæ is curious but presumably without special significance. It is also a coincidence that the writer had arranged these six types in this order before deriving the formulæ.

As regards the accuracy of the approximate formulæ, Table II gives the value of $\frac{M}{M_0}$ to four

Fig. 2.



figures, while the curves in Fig. 1 show the percentage error of (*a*), (*b*) and (*c*) over the whole range of K from 0 to 1. It will be observed that (*b*) has no error, while (*a*) and (*c*) lie within 3 per cent. and

TABLE I.

Loading.	$\frac{M}{M_0}$ Exact Formula.	$\frac{M}{M_0}$ Approx. Formula.
(*a*) Free. Equal end couples	$\sec\theta$	1 + 6 B
(*b*) Free. Uniform load ..	$\frac{2}{\theta^2}(\sec\theta - 1)$ ..	1 + 5 B
(*c*) Free. Central load ..	$\frac{1}{\theta}\tan\theta$	1 + 4 B
(*d*) Encastré. Uniform load ..	$\left(\frac{6}{\theta^2} - 2\right)\sec\theta - \frac{6}{\theta^2}$	1 + 3 B
(*e*) Encastré. Central load ..	$\frac{2}{\theta}\tan\theta - \sec\theta$ ..	1 + 2 B

2 per cent., respectively. When K = 0·9, (*d*) has an error of 8·9 per cent. and (*e*) an error of 12·7 per cent.

The last two cases, (*d*) and (*e*), are the simplest types of combined lateral load and terminal couples, and they act so as to give bending moments of opposite signs respectively. Furthermore, it can be shown that

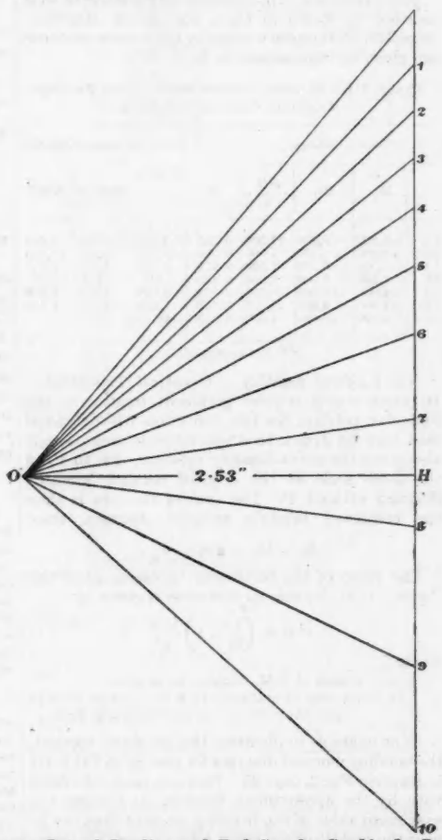
$$\left(\frac{M}{M_0}\right)_d = 3\left(\frac{M}{M_0}\right)_b - 2\left(\frac{M}{M_0}\right)_a,$$

and

$$\left(\frac{M}{M_0}\right)_e = 2\left(\frac{M}{M_0}\right)_c - \left(\frac{M}{M_0}\right)_a.$$

As a matter of interest it will be noted that both the exact and approximate formulæ conform to this relation.

Clearly small errors in each term of (*d*) and (*e*) will produce greatly magnified errors in their differences, and this accounts for the greater divergence of these expressions from the exact ones. This fault, however, will also arise in any departure from the ideal presupposed conditions, or in any numerical discrepancies in the awkward computations involved in the exact formulæ. It is therefore suggested that the essential divergencies are those contained in the first three cases.



Lateral Loading and End Couples Combined.—In the more general case of uniform loading w and

TABLE II.—*Values of* $\frac{M_{max.}}{M_0}$.

Type of Loading.	Value of $\frac{P}{P_e}$ (K).				
	0·1.	0·3.	0·5.	0·7.	0·9.
(*a*) Equal end couples	1·137	1·533	2·253	3·941	12·42
(*b*) Free. Uniform load	1·137	1·529	2·234	3·879	12·11
(*c*) Free. Central load	1·114	1·441	2·030	3·405	10·28
(*d*) Encastré. Uniform load	1·114	1·441	2·030	3·403	10·27
(*e*) Encastré. Central load	1·092	1·351	1·819	2·899	8·293
	1·092	1·353	1·822	2·910	8·402
	1·151	1·257	1·584	2·233	6·010
	1·154	1·264	1·617	2·440	6·550
	1·047	1·170	1·385	1·857	4·17
	1·046	1·176	1·411	1·959	4·70

Note.—In each case the upper figure given is computed by exact formula and the lower figure by the approximate formula.

unequal end couples M_1 and M_2, the orthodox solution of the differential equation gives

$$M_{max.} = \sqrt{C^2 + D^2} - \frac{w\,l^2}{4\,\theta^2},$$

where

$$C = M_1 + \frac{w l^2}{4 \theta^2},$$

and

$$D = \left(M_2 + \frac{w l^2}{4 \theta^2}\right) \operatorname{cosec} 2\theta - \left(M_1 + \frac{w l^2}{4 \theta^2}\right) \cot 2\theta.$$

The corresponding approximate formula, on the same assumption, is

$$M_{max.} = \frac{M_1 + M_2}{2}(1 + 6B) + \frac{w l^2}{8}(1 + 5B) + \frac{(M_1 - M_2)^2}{2 w l^2}. \quad . \quad . \quad . \quad (2)$$

It may be noted that the latter expression is derived as before, directly from $M = M_0 + Pd$, without solving any further differential equation, but with the additional approximations :—

(*a*) The maximum deflection due to M_1 and M_2 is equivalent to the maximum deflection due to equal couples $\frac{M_1 + M_2}{2}$,

(*b*) The total maximum deflection equals the sum of the separate maximum deflections.

The expression (2), above, is very similar to that ascribed to Webb in Case, *Strength of Materials*, page 349. Examples worked by the various methods are given for comparison in Table III.

TABLE III.—*Terminal Couples and Uniform Loading. Maximum B.M. by Calculation.*

	Data.				Exact.	Approximation.	
	M_1.	M_2.	$\frac{w l^2}{8}$.	K.		Eqn.(2).	Webb.
(*a*)	−5,200	− 8,370	11,000	0·265	5,280	5,342	5,427
(*b*)	−5,200	− 8,370	11,000	0·800	15,350	16,020	15,200
(*c*)	−3,000	− 8,370	7,500	0·674	3,450	3,505	3,250
(*d*)	−4,000	− 3,000	3,055	0·429	−410	−475	−396
(*e*)	−4,000	−10,800	10,368	0·398	4,246	4,238	4,298
(*f*)	−4,000	− 4,000	2,592	0·107	−1,676	−1,680	−1,755
(*g*)	−4,000	−12,000	4,000	0·455	−12,120	*	?

* Not applicable.

Non-Uniform Loading. Graphical Treatment.—In cases which require graphical treatment, the funicular polygon for the deflection without axial load may be drawn to a special scale such that it also gives the extra bending moment, due to P, to the same scale as the original bending moment diagram without P. The sum of the two is then the combined bending moment diagram, since

$$M = M_0 - P\delta_0 \frac{1}{1 - K}.$$

The value of the horizontal displacement of the "pole," O H, for this special scale is given by

$$O H = \left(\frac{1}{K} - 1\right) \frac{L}{n^2},$$

where

L = length of B.M. diagram as drawn.

n = number of ordinates of B.M. diagram used to give the "loads" in the reciprocal figure.

As an example to illustrate this graphical method, the bending moment diagram for case (*g*) in Table III is drawn in Fig. 2, page 25. This case cannot be dealt with by the approximate formula (2) because the maximum value of the bending moment does not lie near the middle of the beam-column, and it is therefore suitable for graphical solution. In the diagram, the full line indicates the bending moment without P, and the dotted line that with P. The agreement of the maximum bending moment with the calculated value, namely − 12,120, will be noted, and its position also corresponds with that computed from the exact formula. The data used in the preparation of the diagram are as follows : $M_1 = -4{,}000$; $M_2 = -12{,}000$; $\frac{w l^2}{8} = 4{,}000$; $\frac{P}{P_e} = 0{\cdot}445$; L = 2 in.; $n = 10$; $O H = \left(\frac{1}{0{\cdot}445} - 1\right) \frac{2 \times 10}{n^2} = \frac{25}{n^2} = 2{\cdot}53$ in.

Continuous Beam-Columns.—The usual method of dealing with a beam-column that extends over several supports is to equate the slope on each side of a support, and by this means determine the unknown bending moment over the support. Each bay can then be considered separately as a beam-column with lateral loading and end couples combined. This is the standard "three moments" treatment for beams, but, when applied to beam-columns, the equation for the slope is more complex and the solution of the problem involves awkward terms.

It is suggested that the same approximation that has been used for the deflection of beam-columns should equally apply to the slope, because, if the ordinates of any curve are increased in a definite ratio throughout, the slope of the curve is increased in the same ratio at every point. Adopting this condition to a continuous beam-column in the neighbourhood of a support, we find that the slope using suffixes 1 and 2 to denote bays A B and B C, respectively (see Fig. 3, page 25),

$$\alpha = \frac{1}{1 - K_1}\left(\frac{dy_1}{dx_1}\right)_{x = l_1} = \frac{1}{1 - K_2}\left(\frac{dy_2}{dx_2}\right)_{x = 0}.$$

If the beam-column is of the same section throughout, this leads very simply to a modified "three moments" equation for a uniformly distributed lateral load

$$M_A + 2M_B + \frac{w_1 l_1^2}{4} = -\frac{1 - K_1}{l_1}\frac{l_2}{1 - K_2}\left(2M_B + M_C + \frac{w_2 l_2^2}{4}\right), \quad . \quad . \quad . \quad (3)$$

or more generally, for any lateral loading, with the substitution of

$$\frac{6}{l_1^2}\int_A^B M x\,dx \text{ for } \frac{w_1 l_1^2}{4}, \text{ and } \frac{6}{l_2^2}\int_C^B M x\,dx \text{ for } \frac{w_2 l_2^2}{4}.$$

The standard solution is

$$f(\theta_1) M_A + 2M_B \phi(\theta_1) + \frac{w_1 l_1^2}{4}\psi(\theta_1) = -\frac{l_2}{l_1}\left[f(\theta_2) M_C + 2M_B \phi(\theta_2) + \frac{w_2 l_2^2}{4}\psi(\theta_2)\right]$$

where *f*, ϕ, and ψ are the "Berry" functions.

The computation by "Berry" tables is laborious, and only three examples have been worked for purposes of comparison. These are taken from Case, *Strength of Materials*, page 352, and Niles and Newell, *Airplane Structures*, vol. II, page 82, and they show differences of − 17·4 per cent., − 4 per cent., and − 3·3 per cent. The first of these discrepancies is considerable, and rather surprising in view of the very fair agreement of the preceding results. Experimental verification could easily be carried out and would be interesting.

BRITISH EXHIBITION, COPENHAGEN.—The Board of Trade have announced that arrangements have been made, with the approval of H.M. Government and the Danish Government, to hold an All-British Exhibition in Copenhagen in September, 1948. The exhibition will be organised by the British Import Union of Copenhagen in collaboration with the Federation of British Industries, as was done in the case of the successful British Exhibition in Copenhagen in 1932. Further announcements will be made in due course.

THE CHEMICAL SOCIETY.—As already announced in our columns, the centenary celebrations of the Chemical Society will take place in London from Monday, July 14, to Wednesday, July 16. On the first day, at 11 a.m., the centenary exhibition will be opened at the Science Museum, South Kensington, S.W.7, by the President of the Society, Professor C. N. Hinshelwood, F.R.S. This will illustrate the history and achievements of British chemistry and much original apparatus used by famous pioneers will be on view, most of it for the first time. The exhibition will remain open until September 30. On Tuesday, July 15, at 9.45 a.m., there will be a reception of delegates and visitors by the President and Council, at Central Hall, Westminster, S.W.1. This will be followed, at 11 a.m., by an address of welcome by the President and the presentation of addresses by distinguished visitors. At 3.30 p.m., the President will deliver the centenary address at the Central Hall. On Wednesday, July 16, at 11 a.m., two lectures will be given, the first at the Institution of Civil Engineers, Great George-street, London, S.W.1, by Professor J. Read, F.R.S., on "Chemical Personalities a Century Ago," and the second at the Royal Institution, Albemarle-street, W.1, by Professor E. K. Rideal, M.B.E., F.R.S., on "The Work of the Royal Institution in Physical Chemistry in Great Britain." At 3 p.m., on July 16, in the Central Hall, Westminster, the Faraday Lecture will be delivered by Sir Robert Robinson, F.R.S., and the lecture will be followed by the presentation of the Faraday Medal to the lecturer. Further particulars may be obtained on application to the secretary of the Society, Burlington House, Piccadilly, W.1. The celebrations will be followed by the 11th International Congress of Pure and Applied Chemistry, to be held in London from July 17 to 24.

PERMANENT-MAGNET EDDY-CURRENT DYNAMOMETER.

By F. G. SPREADBURY.

IN testing sources of small mechanical power, satisfactory loading frequently creates some difficulty; for example, with electric motors of very small horse-power, the Prony brake is too cumbersome, while a string brake puts an undesirable load on the motor bearings. Providing the operating speed is not too low, a satisfactory method of loading small motors is by means of an eddy-current dynamometer. For loading motors with torques up to 10 oz.-in., the writer has designed the dynamometer illustrated in Figs. 1, 2 and 3, opposite. Eddy-current dynamometers are invariably of the electromagnetic type, but that illustrated employs a permanent magnet. The advantages of the latter are that no supply is necessary for energising the field and in consequence, there are no leads to restrict the movement of the stator.

The stator consists of an Alnico magnet, mounted on a ball-race, and carrying four laminated poles as shown in Figs. 4 and 5. The stator also carries an indicator and control weight, and is supported by a stud passing through the ball-race centre. Thus the stator and indicator are free to turn subject to the influence of the control weight. The rotor, illustrated in Figs. 6 and 7, consists of an aluminium cup which is attached to the spindle of the motor undergoing test. In operation the rotor overlaps the stator, the amount of overlap being controlled by adjustment of the lead screw shown in Fig. 2. Thus eddy currents are induced in the cup, and the torque set up between these and the magnet causes a deflection of the latter from which the output of the motor is determined.

Surrounding the periphery of the aluminium cup is a sleeve of mild steel, the principal function of which is to provide a low-reluctance path for the magnetic flux from the magnet poles. Thus the flux passes from a N pole radially across the gap, then through the sleeve, and then recrosses the gap to the S poles. Eddy currents are, of course, also induced in the sleeve but, because of the relatively high specific resistance of this, are small compared with those induced in the aluminium cup.

In order to obtain the torque/speed relationship, consider the developed view of the magnet poles and cup, Fig. 8, where the rotor completely overlaps the stator. If ω and *r*, respectively, are the angular velocity and radius of the rotor, then the e.m.f. induced in the rotor is

$$2B \omega r l 10^{-9} \text{ volts},$$

where B is the flux density in the air gap. The effective path of the eddy currents is shown by the arrow in Fig. 8, and from this, the resistance of the path is

$$\frac{2\left(d + \frac{l}{2}\right)\sigma}{t\frac{l}{2}} = \frac{2(2d + l)\sigma}{t l},$$

where *t* is the thickness of the rotor and σ the specific resistance of the material of which it is formed. Hence the value of the eddy current is

$$I = \frac{B \omega r t l^2 10^{-8}}{(2d + l)\sigma} \text{ amperes.}$$

The torque produced by each of the stator poles is $B I r \frac{l}{10}$ dyne-cms. The total torque is, therefore,

$$T = \frac{n B^2 \omega t r^2 l^3 10^{-8}}{10(2d + l)\sigma} \text{ dyne-cms.}, \quad . \quad (1)$$

where *n* is the number of stator poles ; in the present instance, four. It will be noted that the torque varies directly with the speed of the rotor, and hence the dynamometer functions most satisfactorily when employed for testing high-speed motors. This, of course, is generally the case for all types of eddy-current dynamometers for, unlike the Prony brake, if $\omega = 0$, so also is T. From (1) it is apparent that T is a rapidly increasing function of *l*, the amount

PERMANENT-MAGNET EDDY-CURRENT DYNAMOMETER.

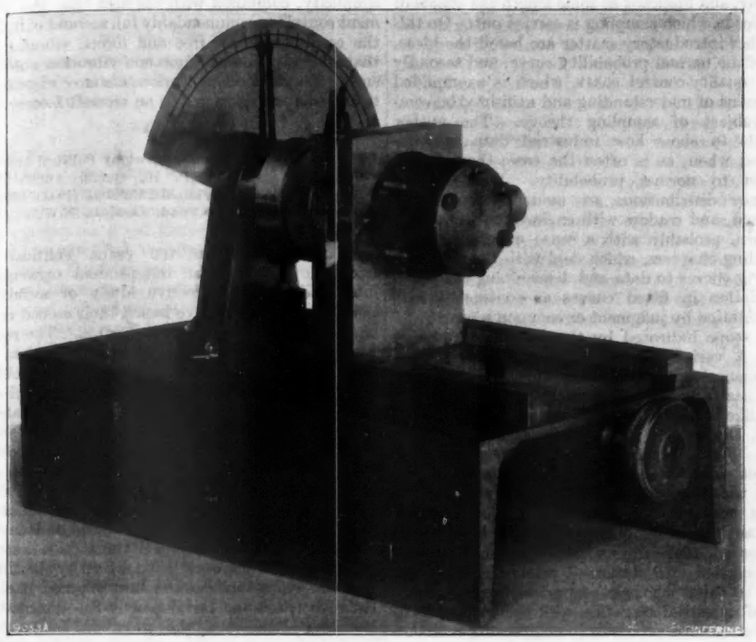
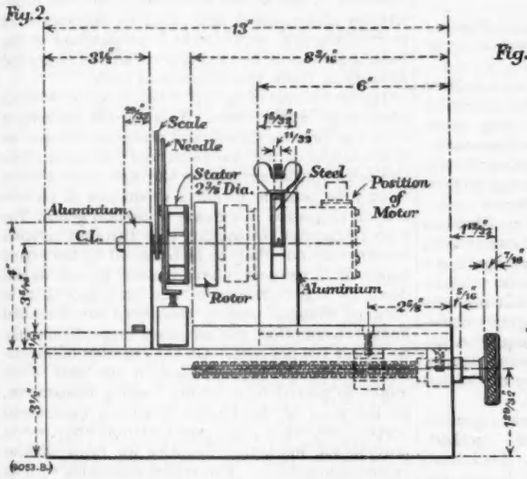
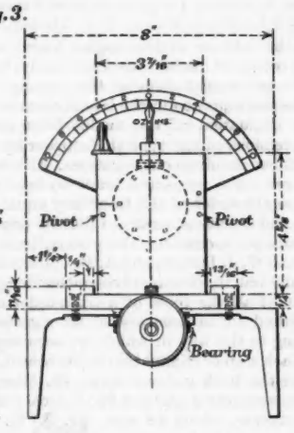
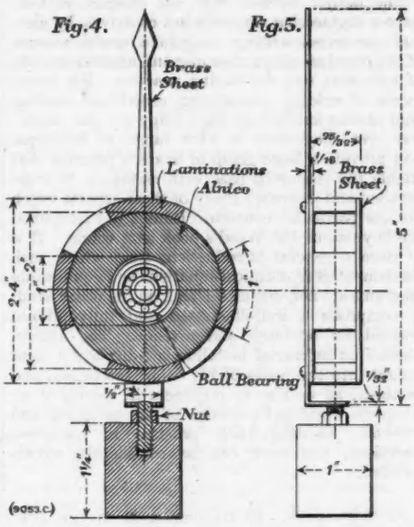
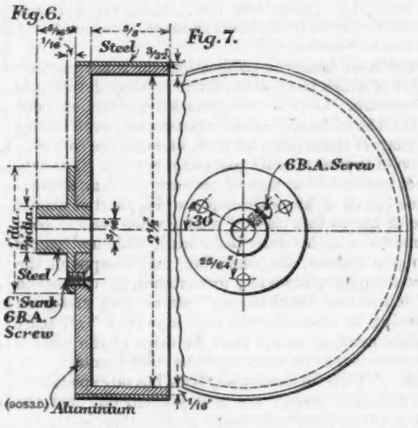


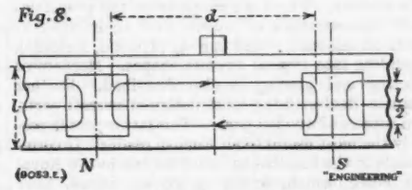
FIG. 1.











of overlap. Equation (1) also indicates that for $l = 0$, $T = 0$. However, even with no overlap a small torque is produced, this being caused by the stray field at the sides of the rotor.

The controlling torque of the dynamometer is effected by gravity, by means of a weight situated on the same diameter as the indicator. If m is the mass of the weight in grammes, and r_c the radius at which it acts, then the restoring torque for an angle of displacement θ is

$$T_r = m\, r_c \sin\theta.$$

For equilibrium $T_r = T$, and hence

$$m\, r_c \sin\theta = \frac{n\, B^2\, \omega\, t\, r^2\, l^2\, 10^{-8}}{10\,(2d + l)\,\sigma},$$

and

$$\theta = \arcsin \frac{n\, B^2\, \omega\, t\, r^2\, l^2\, 10^{-8}}{10\,(2d + l)\,\sigma\, m\, r_c}.$$

From this it will be noted that the scale follows a sine law, being open at the extremities and approximately linear in the vicinity of the origin. As the function of the dynamometer is the measurement of small powers, the speed is conveniently measured by some form of stroboscope.

LITERATURE.

Metallurgical Materials, Alloys and Manufacturing Processes. By V. N. WOOD, A.M.I.B.F. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 25*s.* net.]

IN a brief foreword to this book, Mr. J. W. Gardom, a past-president of the Institute of British Foundrymen, emphasises the value to technicians and artisans alike of knowing as much as possible about the materials with which they work. Mechanical engineers and works metallurgists have long subscribed to this view, but not uncommonly have experienced difficulty in gaining such knowledge from standard text-books, addressed to students aiming at a professional career in metallurgy, which are properly concerned as much or more with the fundamental physics and chemistry of the subject as with the more superficial properties of metals and alloys. Mr. Wood's book therefore fulfils a widely-recognised purpose, not only by enumerating the more important principles underlying the properties, treatment and manufacture of engineering metals, but also by discussing these matters in a simple, succinct and interesting way which technical men with no more than an elementary practical acquaintance with metallurgy will find attractively easy to understand.

With the needs of this sort of reader prominently in mind, the author deals first with the methods of smelting iron ores and of manufacturing steel by various types of furnace, including those operated on the high-frequency induction principle. Two succeeding chapters survey standard methods and apparatus for the mechanical testing and physical examination of metals. They afford the reader a broad view of the scientific approach to the metallurgy of the laboratory, ranging from the simple tensile machine to the electron microscope, but necessarily excluding much of the theoretical and critical matter essential to authoritative interpretation of results. A somewhat similar review of methods and equipment for measuring and controlling temperature in metallurgical practice completes an introduction on which the author bases descriptions of forging and other mechanical working operations on steel, and of the properties of carbon and alloy steels in relation to their composition, heat treatment and mode of fabrication. Two further chapters, dealing respectively with cast and malleable irons from the standpoints of the foundryman and

the engineer, are commendably informative as regards annealing operations and the effects of alloying elements.

The author devotes only one chapter to non-ferrous engineering materials but contrives, by clear and condensed writing, to give a useful account of the principal alloys of copper and aluminium, and of extrusion and die-casting practice. His treatments of welding, galvanising, centrifugal casting, chill casting and powder metallurgy are also discursive, yet they cover a wide range of technique and provide a basic grasp of modern practice that enable the reader to pass with assurance to more detailed and advanced study of those aspects which are his particular concern. Herein is exemplified the keynote of Mr. Wood's book as a whole. It is at once a general introduction, from which such fundamentals as chemical equations and equilibrium diagrams are not excluded; and, on the other hand, it comprises a well-illustrated and fully-indexed manual for reference and revision. The author, himself an industrial metallurgist, displays a clear insight into the needs of his fellow craftsmen, and to them, as well as to engineers in search of an adequate working knowledge of the materials and processes affecting their practice in numerous directions, this book can be confidently recommended.

Aircraft Woodwork. By COLONEL R. H. DRAKE, B.S., M.A. The Macmillan Company, 60 Fifth Avenue, New York, 11. [Price 3·50 dols.]. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 18*s.* net.]

THIS is an American publication, the exact counterpart of which is not often found in English technical literature. It is a very detailed instruction book upon the technique of the woodworker, even having a chapter illustrating his tools, and uses the construction of typical aircraft parts as examples. The subject matter is that part of the work which an apprentice learns in his workshop training, and it should be of use to this class of reader when read in conjunction with his daily task, but it seldom attempts to give reasons, and, therefore, may disappoint the more inquiring student; for instance, the chapter on "Joints and Laminations" states that end-grain glueing is unsatisfactory and says that "all scarf joints must be so cut that the slope of the joint is great enough to overcome the disadvantage" of this. This is fundamentally true, but no explanation or reason is given; nor is it pointed out that the slope of the scarf suggested is greater than is usual in this country. There are chapters on the properties and characteristics of woods, and their defects; hints on selection; and one on plywood, including moulding into typical aircraft shapes. Mechanical jointing and glueing is also described. Further chapters deal with the construction of aircraft parts, and repairs of wooden parts. This latter part is possibly the most useful to an English reader. It corresponds to the handbooks issued for use in the Royal Air Force, which, so far as we are aware, have never been available to the public. The book might well be used as an instruction manual for aircraft woodworking apprentices, in the absence of anything more nearly descriptive of English practice.

Examination of Industrial Measurements. By JOHN W. DUDLEY, JR. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York, 18. [Price 2 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, London, W.C.2. [Price 10*s.*]

DESPITE the increasing use and appreciation of statistical methods for analysing industrial information, the subject is not one which the general run of technical workers find either interesting or easy to understand. The nomenclature is troublesome in the early stages, and the mathematical operations, while seldom inherently difficult, are in many ways unfamiliar. A thorough grasp of the fundamental principles is not easily acquired and a certain amount of prejudice against statistical manipulations tends rather to be confirmed than otherwise by the formidable appearance of the work. Mr. Dudley has endeavoured (unfortunately, without complete success) to surmount such obstacles in his presentation of some of the more adaptable methods of analysis intended for application in production engineering. He emphasises at an early stage the importance of collecting and presenting data correctly, and discusses at some length the effects of the order in which sampling is carried out. On this and other introductory matter are based the ideas, first, of the normal probability curve, and secondly of the quality-control chart, which is exemplified as a means of understanding and utilising the complex subject of sampling theory. The author proceeds to show how industrial data may be analysed when, as is often the case, they do not conform to normal probability. Such skewed frequency distributions are evidently not easily explained, and readers with engineering knowledge will turn, probably with a sense of relief, to the concluding chapters, which deal with the problems of fitting curves to data and determining the limits of variation in fitted curves as contrasted with interpretation by judgment or common sense.

The scope indicated by the foregoing summary covers a varied selection of the inspection and experimental operations encountered by engineers, but it has to be admitted that many of those who would like to apply the statistical analyses reviewed by Mr. Dudley will find his text somewhat heavy going. For one thing, the writing is unusually compact, and, for another, the minimum of mathematics that the author has found it necessary to include accounts for a considerable and highly important proportion of his work. The book should be regarded, therefore, as hardly appropriate for a first incursion into statistical principles, but more suited to those who, already possessing a groundwork of industrial statistics, seek the best methods of applying those processes to engineering problems in general and quality control in particular.

The Escalator Method in Engineering Vibration Problems. By J. MORRIS. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 21*s.* net.]

IN the solution of Lagrangian frequency equations the orthodox method involves, firstly, the expansion into polynomial form of the characteristic determinantal equation in the latent roots and, secondly, the evaluation of the modes from determinantal expressions of the type that appear in the solution of linear simultaneous equations. Although straightforward, the procedure tends to become laborious when the order of the frequency equations exceeds six and results accurate to four or more significant figures are required. The matrix iteration method, due to W. J. Duncan and A. R. Collar, is an improvement, but it, too, involves rather lengthy calculations if all the roots of a sixth-order equation are required to an accuracy of six significant figures, owing to the way in which the accuracy diminishes as each step or elimination is performed.

In the book under review, Mr. Morris expounds in a systematic manner the "escalator" method, or process, which he and Mr. J. W. Head have developed for the numerical solution of Lagrangian frequency equations of much higher orders. The procedure differs from those already mentioned in several important particulars: it does not involve the evaluation of determinants or the use of iteration, but proceeds by successive introduction or elimination of the various generalised co-ordinates in any order which the computer may desire. Hence the calculations may be carried forward to a considerable extent, even when some of the stiffness coefficients are unknown, and the effect of variations in one part of the structure can be examined without much trouble by operating the method in reverse.

An instructive summary of the related problem of structural stiffness occupies the first seven chapters, and into this has been incorporated an extension of Professor Hardy Cross's method of moment distribution. After describing the analytical foundation of the escalator process, Mr. Morris applies it to a wide variety of vibration problems, especially those likely to arise in the design of aircraft. Thus the work as a whole elucidates the analytical treatment of such components as tapered rods resembling the blades of an airscrew, and the multiple propeller and gearing system, as well as the more general problem of coupled fuselage roll and anti-symmetrical wing vibration on the one hand and, on the other, pitching and yawing movements and their coupling with airscrew vibrations. The general applicability of the method and its amplicity, combined with the fact that this treatment contains a commendably full account of it, from the consideration of free and forced vibrations to that of the pendulum dynamic vibration absorber, ensure the value of the work as a source of guidance to the computer engaged in an aircraft factory.

Britain and World Trade. Report by Political and Economic Planning. PEP, 16, Queen Anne's Gate, London, S.W.1, and Simpkin Marshall (1941), Limited, Rossmore-court, Park-road, London, N.W.1. [Price 12*s.*]

AFTER an interval of ten years, Political and Economic Planning, an independent organisation interested in the objective study of social and economic questions, have issued their second report on the subject of international trade. The report, which contains 199 pages, including an index, presents a detailed analysis of world trading problems and policies, with particular reference to Britain's position and the influence of the United States of America upon the economic stability of other countries. The first part of the report is concerned with world trade and employment. It discusses the political and commercial circumstances which attended the breakdown during the inter-war period and suggests measures for the avoidance of a repetition. The last chapter in this section describes the economic framework being set up by the United Nations, which includes the International Bank for Reconstruction and Development, the International Monetary Fund and the proposed International Trade Organisation. The relation of these agencies to a system of universal multi-lateral trade, which is favoured by the report, is explained, and the necessity for international agreement on the means for maintaining full employment is emphasised as the basic requirement for raising standards of living and developing trade throughout the world.

The second part of the report is devoted to Britain's position in world trade. This section includes a review of pre-war figures and war-time changes, an examination of the American and Canadian loans, and considerations regarding the directions in which it may be possible to effect economies in imports and an expansion in exports of certain goods. The report expresses the opinion that Britain's national accounts are not likely to be balanced by the export target of 75 per cent. above pre-war figures, as laid down by the Government, and considers that, in view of changed trading conditions and increased home consumption, the necessary target figure may be nearer 100 per cent. On the question of increasing exports, the report discusses the part which might be played by a Public Trading Corporation, on the lines of the United Kingdom Commercial Corporation, which, as a governmental body, would provide the marketing facilities for firms without export connections. The report concludes with an investigation into the effects of an American slump upon Britain, and corrective measures, designed to ward off consequent unemployment and internal depression in this country, are proposed. In both parts of the book, conclusions and recommendations are summarised, and the report contains many tables of import and export statistics for the United Kingdom and the United States.

L.N.E.R. PREFABRICATED TRACK.—The L.N.E.R. have recently relaid a section of a junction at the approach to the sorting yard at Guide Bridge, in the Manchester district, with prefabricated track, a method which reduces the "occupation" time on the site. The section, which was constructed in a nearby yard in 16 working hours by 20 men and a crane-driver, measured 170 ft. in length, and 26 ft. in width, and weighed 35 tons. It was divided into seven sub-sections for transport to the site early on a Sunday morning. The clearing of the ballast and lifting of the old track was started at 7 a.m. At 10.30 a.m. the first of the new sub-sections was laid, and by 3 p.m. the work was completed. The line was therefore occupied for eight hours—two hours less than the time allowed by the operating department, and considerably less than would have been required for relaying the track by the conventional method of constructing it on the site.

THE INTERNATIONAL RAILWAY CONGRESS, LUCERNE.

(*Continued from page* 18.)

WE continue below our summary of the reports on sleepers, having dealt with wood sleepers in last week's issue.

STEEL SLEEPERS.

Certain countries which are large exporters of steel, and others where termites would attack wood sleepers, have developed the use of steel sleepers. The Swiss railways have decided that metal sleepers are superior to wood sleepers, and that their use should be extended, despite the comparatively high first cost. Other railways, however, have not been disposed to use metal sleepers, except during periods of timber shortage. Steel sleepers are usually trough-shaped, made from rolled mild-steel, and die-stamped hot to form the splayed ends and certain other details. There has been a tendency to reduce the length of steel sleepers from 8 ft. 10 in. to 8 ft. 3 in. or less, for standard-gauge lines. The width at the base is usually about 9¼ in., and the height about 3½ in. The weight varies from 110 lb. to 187 lb. Bull-headed rails are secured to steel sleepers with chairs. Flat-bottomed rails are secured by direct fastening to the sleeper, which has the advantage of minimising the metal-to-metal wearing surfaces; or by direct fastenings with a base-plate between the rail and the sleeper; or by indirect fastenings with a base-plate. When the rail is laid directly on the sleeper, the cant is obtained by manufacturing the sleeper with an inclined bearing surface. There is a considerable variety of hook-bolts, clips, etc., for fastening the rail to the sleeper, and most of them incorporate simple means for spreading the track gauge on curves. In the few remaining cases, sleepers are made in different sizes. An elastic packing piece of treated wood or rubber is sometimes placed between the rail and sleeper to reduce wear, give improved flexibility, and diminish noise. Granulated slag, freshly crushed slag and ashes have a corrosive effect on metal sleepers, but it is not sufficient to preclude their use. Steel sleepers are preferred to wood sleepers in or near engine sheds, as although cinders have a corrosive effect on steel, this is not so serious as their burning effect on wood.

The most serious drawback associated with metal sleepers, however, is that they cannot be used on lines equipped with track-circuiting, unless some form of insulation is used. The Swiss Federal Railways, on which two-thirds of the tracks are equipped with metal sleepers, report that they are experimenting with an arrangement consisting of insulating plates inserted between the rails and the sleepers, and between the rails and the sleeper clips. A steel sleeper is usually rendered unserviceable by corrosion or wear of the bearing surfaces, or the formation of cracks round the rail seat, or the bending of the sleeper (or the jaws of the pressed-up lug type). Mr. O. Leduc reported that metal sleepers usually last longer than wood sleepers, and that a reduction in thickness due to rust, sufficient to warrant scrapping, does not usually occur until about 50 years. Repairs to steel sleepers are of two kinds. Cracks, which usually occur at the corners of slots (even if these have been rounded), are repaired by welding; and worn bearing surfaces are restored by welding on a patch. Worn sleepers, and sleepers repaired by these means, are used for less-important lines, although they may be already 45 years old. Sleepers are sometimes fabricated from the sound parts of several worn ones. Those that are no longer suited to their original function, may be used for fences, walls, or revetments of ditches.

CONCRETE SLEEPERS.

The shortage of timber and steel after the two world wars encouraged the development of concrete sleepers, and although experiments have been made in several countries, they have not been entirely satisfactory, and further attempts are being made. There are three principal types, usually of reinforced concrete: a complete sleeper, similar to a conventional wood sleeper; a series of pairs of concrete blocks or "pots," each pair joined by a tie-bar, or a certain proportion so joined; and continuous-beam longitudinal supports. In this country, the four main-line companies are experimenting with pre-stressed and ordinary reinforced-concrete sleepers, the former being more satisfactory. Bull-head rails are invariably used in these cases. Each sleeper is about 8 ft. in length, about 10 in. wide, and 6 in. to 8 in. deep, and weighs about 500 lb. Many experiments have been made on the Continent, especially in France, where both through sleepers and blocks are in use. The electrical resistance of concrete sleepers is generally reported to be lower than that of wood sleepers, and, although an insulated design was brought out in France, it was too expensive. Research was therefore undertaken in that country, and it demonstrated that the resistance of concrete depended on its degree of porosity. The method of manufacture has consequently been altered to ensure very dense concrete, which is an efficient insulator, and the French National Railways intend to develop the idea.

The failures of concrete sleepers so far experienced by the railways providing information, show that the concrete ultimately cracks and exposes the reinforcement. Concrete sleepers are usually laid by hand, although the London and North Eastern Railway pre-assemble 30-ft. lengths of track, using old rails, for transporting to the site; the length is then laid by crane, the old rails removed, and the new rails placed in position. It is generally conceded that large-size ballast is unsuitable for concrete sleepers. Trials with continuous-beam longitudinal supports are being undertaken by the London and North Eastern Railway and the French National Railways. The former, who require a track involving the least possible inspection and maintenance, for use especially in tunnels, are using concrete beams weighing 31 cwt., 15 ft. in length, 11 in. deep, 2 ft. wide, and containing 457 lb. of steel reinforcement. Gauge is maintained by transverse angle pieces at 7 ft. 6 in. pitch; 110-lb. flat-bottom rails are secured by clips and mushroom-head bolts which screw into a cast-iron insert in the concrete; a timber or rubber cushion is fitted under the rail; and spring-washers are used at all connections. The beams are laid on two types of foundation: bituminous-concrete 9 ft. wide and 6 in. thick; and two longitudinal reinforced aluminous-cement concrete foundations (each 3 ft. wide by 9 in. thick). With both types of foundation the space between the beams is drained through a gully and pipe, and the tracks are ballasted to the underside of the tie-bars. On the French National Railways the beams are each 4 ft. 1½ in. long, 2 ft. 3½ in. wide, and 5½ in. thick These are laid directly on ballast, and the gauge is maintained by ordinary wood sleepers between the ends of adjacent beams, or by tie-bars.

MAINTENANCE METHODS.

The care of sleepers includes the correction of level, and the maintenance of the sleepers themselves and their fittings. There seems to be no conclusion as to where the top of the ballast should be in relation to the track, although Mr. Leduc noted that most of the railways reporting to him maintained the ballast level with the top of the sleepers, both inside and outside the track. Hand beating or tamping is still widely used, although it wears away the lower edges of the sleepers and thereby reduces stability. Mr. Leduc referred to the use of several mechanical tamping machines. Shovel-packing gives better results than hand-tamping; it is less laborious, and is being used on an increasing number of systems. It can also be used for concrete sleepers, and—less easily—for steel sleepers. When coach-screws work loose they may be replaced by larger ones or the holes may be restored by one of several methods, if the wood is still sound: by plugging the hole with a malleable metal plug; by plugging with a hardwood plug and re-drilling, and by drilling out the old hole, fitting a dowel, and drilling. Splits are repaired by the processes which have already been mentioned. Most maintenance operations, such as screwing and unscrewing coach-screws, drilling, adzing, hooping, and fitting and removing spikes, may be mechanised with advantage. The maintenance of steel sleepers is generally limited to tightening fastenings, and repairing cracks in the corners of the slots by welding. The latter work usually, but not always, necessitates the removal of the sleepers to a repair shop. No repairs to concrete sleepers, other than tightening fastenings, were reported. Reference has already been made to the practice of renewing all sleepers in a section, which is common practice in Great Britain, and is finding increasing acceptance in other countries.

COMPARATIVE COSTS.

Owing to the difficulty of making financial comparisons between one country and another, it is only possible to draw certain general conclusions from the information supplied by the railways. In view of their shorter life, and higher cost of impregnation and maintenance, soft-wood sleepers cost more per annum than hardwood sleepers, although their first cost is less. Impregnation with preservative prolongs the life of sleepers considerably, but the reports do not give sufficient information to show whether or not the additional expense is offset by the saving due to increased life. Despite the higher cost price, metal sleepers, in certain cases, cost less per year of service than wood sleepers. The first cost of concrete sleepers is greater than that of steel or timber sleepers but if, by improved design and methods of manufacture, their life can be extended to 45 or 50 years, they will be able to compete in terms of cost per year of service. At present, there has not been sufficient experience of concrete sleepers to enable reasonable comparisons to be made. Mr. Leduc gives a report of the examination of this problem which has been undertaken by the French National Railways, and he reaches the conclusion that concrete sleepers should first be used on lines carrying comparatively slow, light traffic, where stresses are small, and where the full benefit of the long life of concrete, and the savings in maintenance due to their use, may be gained. On such lines, the life of wood sleepers is usually limited by rot and not by wear. The use of steel sleepers may also, with advantage, be similarly extended. He suggests that hardwood sleepers should be reserved for lines carrying heavy, fast traffic, although experiments should also be conducted with concrete sleepers on these lines. Concrete sleepers are heavy and therefore demand special equipment for laying them. On the other hand, since the replacement of isolated sleepers disturbs the foundation and thereby increases the cost of maintenance, concrete or steel sleepers show a saving compared with wood sleepers, which have to be replaced individually more frequently, due to burns, for example. There is still, however, the problem of providing an effective, economical insulation in steel and concrete sleepers for track-circuiting purposes.

The laying of rails on sole-plates, especially with indirect fastenings, reduces the wear of wood sleepers and, in consequence, the maintenance costs, but there is no evidence to show whether the increased cost (reported by Mr. Leduc to be about one-third) is offset by the savings; and it may be that, on lines with small axle-loads, there is no real economy. Of the three principal methods of maintaining track level, the cheapest is measured shovel packing, and the most expensive is hand tamping, with pneumatic and electric tamping between the two. Mr. Leduc reports that measured shovel packing is the least harmful to the sleepers, and can be used with wood, steel, or concrete sleepers, but Mr. Train suggests that "track packed by means of power beaters stands up longer than when packed by other means." Mr. Leduc also notes that "most railways using wood, steel, and concrete sleepers state that the cost of maintaining the level is higher in the case of the last-named, whatever method be used." The French National Railways are an exception to this conclusion, because, since they consider the most important part of the work of maintaining the level is the removal and replacement of the top layer of ballast, and since the quantity of such ballast is less with metal sleepers than with wood sleepers, and still less with concrete sleepers, they find that both shovel packing and tamping cost less for steel sleepers and still less for concrete sleepers.

(*To be continued.*)

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

(*Concluded from page* 19.)

ON Thursday morning, June 26, a meeting of the Incorporated Municipal Electrical Association was held in the Pavilion, Bournemouth, when a paper on "The Law Relating to Electricity Supply" was read by Mr. R. Birt. This was divided into two parts. The first of these summarised the general law which is contained in fourteen general Acts of Parliament beginning with the Electric Lighting Act, 1882, and ending with the Electricity Bill, 1947. Reference was also made to the private Acts of Parliament, numbering over two hundred, and the provisional and special Orders, of which there were about five hundred, dealing with the supply of electricity. In addition, the findings of a number of committees, which in some cases had been embodied in subsequent legislation, were recorded. The second part of the paper outlined the more important amendments and additions to electrical legislation which would result from the provisions of the Electricity Bill, 1947. From these it was apparent that drastic and far-reaching changes in the law relating to electricity supply would be made. It had been the constant desire of the Incorporated Municipal Electrical Association to obtain codification and simplification of the Electricity Acts. In the debate on the second reading of the new Bill in the House of Commons on Monday, February 3, 1947, Mr. Goodrich had appealed to the Minister "to consolidate all the statutes" involved as soon as possible, and Colonel Elliot pointed out that "the electricity law will not be complete until the Minister has made 24 sets of regulations under the Bill, until he has examined 500 provisional and special orders, and over 200 special Acts to discover whether their provisions are inconsistent with or rendered redundant by the new Act, and until the Minister by Order repeals, amends or extends any of the above-mentioned 700 statutory enactments so as to obtain a uniform statutory code." It was the author's opinion that in local enactments there were provisions of general application which, with advantage to all concerned, could be extended throughout the electricity-supply industry. An early opportunity should be taken, therefore, to codify the various electricity Acts into one comprehensive measure Until that could be done, he appealed to the Minister of Fuel and Power to provide a reprint of the Electricity Acts as amended by the Bill and a comprehensive index or explanatory memorandum of the Acts, with adequate cross-referencing of substitute provisions.

Mr. N. Elliott opened the discussion on this paper by pointing out that certain authorities had special powers, and expressing the hope that under the new scheme there would be a general codification, which would ensure uniformity of practice throughout the country. Otherwise the Central Authority would possess powers in some areas that they did not possess in others.

Mr. R. A. S. Thwaites said that clauses 19 and 20 of the Electric Lighting Act, 1882, would be repealed by the new Bill. These were originally designed to protect the consumer; and it was necessary to be assured that this protection would be continued in future. It was satisfactory to know that the Boards could adopt the Local Government Superannuation Act. He strongly supported the plea that there should be codification of the legislation relating to electricity supply. The schedule to the new Bill contained 14 pages of modifications to existing Acts, and some publication summarising the position in clearly understood terms was therefore essential.

Mr. F. Newey pointed out that there had been very few disputes between the 10,000,000 consumers and the electricity supply undertakings, and he hoped that nothing would be done to change that state of affairs. He also supported the plea for codification. For some years consumers had been asked to pay deposits in respect of their accounts and had received 4 per cent. interest on these sums. For this reason, he had been requested to allow the deposit to be increased, as so high a rate of interest could not be obtained from the banks. Moreover, the new authority would be raising money at only 2½ per cent. Compensation was to be provided for "workers" in the industry. This term should include engineers and managers, in view of the contribution they had made to the success of the industry during the past fifty years.

Mr. J. Eccles thought that, by and large, the new Bill was a sensible and necessary measure. Its application and interpretation, however, were more important than its verbal content and the rules made under it. There would be full scope for the initiative and zeal of all engaged in the industry, and if these were applied they could look forward to far greater development than had been made in the past. The Association had never been in conflict with the main principles of the Bill.

Sir William Walker wondered how the global sum of 5,000,000*l.* was to be distributed. If it was to be used to compensate for loss of rates and other things, it would not go far, although it might be sufficient to provide for "severance." The Bill would do great injustice to local authorities if its wording was strictly applied. He hoped that the effective machinery which had been built up to deal with labour relationships in the industry would not be destroyed.

Lord Citrine said that although he had been in office for ten days he had not yet learned all about the industry. He was very pleased that the Minister had selected such a capable band of colleagues for him. At the moment he was concerned with the structure of the organisation that was to be built up. In these matters the legislative phase was often the easiest; and they must be sure not only that the structure was right, but that they obtained the right men to run the industry. He hoped that the transition to the new order of things would be made with the minimum of disturbance. In this connection, any proposals that were made to secure the continuance of the work the Association had been doing would be considered.

Mr. Birt replied briefly to the discussion.

In the evening, the Annual Dinner was held in the Pavilion, the President being in the chair. Proposing the toast of "The Association" Professor J. D. Cockcroft referred to the fact that both the President and himself had worked under Miles Walker whose great virtue was that he insisted on the study of every electrical problem from the standpoint of fundamental physics. The recent crisis had had the effect of forcing us to think seriously about our fuel supplies; and there had been a tendency to look for salvation to atomic or nuclear energy. While this form of energy had great potentialities, and it was worth a determined effort to develop it, it was far from certain how important it would become within the next 10 to 20 years. We should not therefore be distracted by its rather dazzling promise from a search for economy in the use of our present standard fuels. As a physicist he was struck by the low overall efficiency of the thermal utilisation of coal. It was probably below 15 per cent., and to this low figure many causes contributed. First there was the large percentage of heat going uselessly into the rivers. Some of this might be removed by district-heating schemes. There was also a large difference in fuel consumption between that of electricity supply and other power producers. Moreover, our domestic heating systems had a low efficiency which would be improved by the use of better equipment and the better thermal insulation of our buildings. It should also be possible to employ the heat pump for space heating on a large scale. The electricity supply industry was in a key position in regard to the fuel situation, and would be equally so in any developments of atomic energy.

In reply to the toast, the President said that he was interested in the remark that during five years 500,000,000*l.* had been spent on atomic energy research, because in this country only one-tenth of that amount had been spent on electrical research. It was a pity that the report stage of the Electricity Bill had been taking place during the Convention, as this had made it difficult to keep in touch with what was going on. When the Bill became an Act, the main difficulty would not be on the administrative side, but in maintaining the existing spirit of cordiality in the industry.

The toast of "The Guests" was proposed by Mr. J. Eccles. The President of the Institution of Electrical Engineers (Mr. V. Z. de Ferranti) replied.

The annual general meeting of the Association was held on Friday morning, June 27. After the annual report and accounts had been adopted without discussion, Councillor A. E. Wills proposed a resolution urging the Government to remove the purchase tax entirely from electric cookers, wash boilers and water heaters. After an amendment to include refrigerators had been accepted, the resolution was carried unanimously. Alderman A. E. Gough proposed a resolution asking the Council to consider the future of the Association in view of impending legislation. This was also carried unanimously. Councillor G. S. Hyde proposed a resolution which sought to ensure that local authorities should be compensated for any losses incurred in the operation of electricity undertakings, where those losses exceeded the aggregate amount of any contributions that had been made towards the relief of the rates. After some discussion this was carried by a large majority.

Mr. J. Eccles, city electrical engineer, Liverpool, was elected President of the Association for the ensuing year. Councillor J. Selwyn-Jones was elected vice-president, and Mr. W. P. Lilwall, formerly borough electrical engineer at Fleetwood, an honorary member.

STANDARD ROAD-LIGHTING SCHEMES.—In reply to a question by Mr. S. Marshall in the House of Commons on Monday, July 7, the Minister of Transport (the Rt. Hon. A. Barnes) said that comparatively few schemes for the provision of standard forms of lighting on main and trunk roads were proceeding. In conditions now obtaining as to labour, materials and fuel, approval for new and extended lighting schemes could only be given when these were essential for the safety of traffic.

PRESENT PROBLEMS IN THE FOUNDRY INDUSTRY.*

By PERCY H. WILSON, O.B.E., M.I.Mech.E.

DURING my long association with the ironfounding industry it has been my privilege, for the greater part of this time, to have been connected with the Institute, and to follow its steady development throughout the industry, until we have to-day an organisation which undoubtedly compares very favourably with any other body representing a section of the industrial life of our country.

Credit must be given for the way in which demobilisation has been effected and for the comparative freedom from large-scale dislocation in our particular industry through labour disputes such as that which followed the first world war. It would be ridiculous to suggest that any Government wishes anything but prosperity for its people, with rising standards of living and security, although many of us have had doubts as to the wisdom and timeliness of recent shortening of hours of production, and have felt that some form of national wages policy was an urgent necessity.

To-day I would like to try to outline the developments of our industry, as though I had had the honour to be commissioned by you here to take a detached view of our future problems. Let me say at the outset that I am not unmindful that most industries are a mixture of large and small units and that the small units usually predominate. This is evidenced by the fact that in the iron-foundry industry, 93 per cent. of the 1,750 foundries in this country employ on an average less than 200 men, and over 50 per cent. have less than 50 employees. The smaller units have many advantages, and if I speak with experience mainly of large units it is not without a full appreciation of the efficiencies and advantages of the smaller foundries. If small units look with some doubts on the possibility of effecting where necessary some of the improvements I am going to suggest, particularly in the direction of training and employee services, they will not, I am sure, overlook the work already being done on a co-operative basis in various other sections of industry to-day.

It is, I am afraid, an undisputed fact that working conditions throughout the foundry trade do not compare favourably with conditions in the so styled lighter industries, some of which have only been established during the last decade. Differences also exist in remuneration between foundry employees and those in these other industries, and they are not sufficiently favourable to the former to compensate for the working conditions which exist in many of our older foundries. However unpalatable it may be, I feel that we have to face the fact that, although it is imperative for the output of castings to be increased at the present time, new labour will not be attracted to our industry unless working conditions are improved to such an extent that the margin of difference between the foundry worker and the employees in the lighter industries is appreciably reduced.

For instance, few will deny that the standard of our foundry buildings is not as high as it should be. Our industry, which dates back over a very long period, is at a disadvantage compared with newer industries from the point of view both of the age of some of our buildings and because extensions have been made on a piecemeal basis. To-day is a difficult time to undertake a programme of rebuilding, but, seriously, I suggest much could be done to improve our existing buildings by way of more adequate lighting and ventilation and the elimination of obnoxious fumes and dust, which would have the immediate effect of providing cleaner and healthier working conditions; also the addition of improved ablution facilities and sanitary arrangements is desirable. I find from experience that many of our older foundries can be considerably improved by painting or spraying the walls with light coloured washable material instead of the customary method of whitewashing.

In common with other sections of the basic industries of this country our foundries have not yet, owing to circumstances beyond our control, regained the standard of productivity, per man employed, which existed prior to September, 1939. To achieve this and, indeed, to improve on the 1939 standard of productivity, we should aim at a complete elimination of all physical operations which can be satisfactorily and economically performed by mechanical aids. During the war period, much valuable work was achieved in new factories by designing or adapting the plant in such a manner as to bring within the physical scope of female labour work normally allocated to men. It would, I think, be regrettable if the experience so gained was lost to industry, especially at a time when one of our main endeavours is to increase the pro-

* Presidential address delivered on Wednesday, June 18, 1947, at the 44th Annual Conference of the Institute of British Foundrymen, at Nottingham. Abridged.

ductivity per man-hour, and once again recruit women workers.

I suggest that, in the first place, we should carefully examine every operation in our works and satisfy ourselves that every ounce of productive energy is being utilised in the most efficient manner. Our labour costs, due to the high rates of pay now prevailing, are such that we cannot, if we are to continue as a first-rate nation, afford to lose the smallest fraction of the effort available. In those foundries where the layout and plant are comparatively modern, quite often the only scope for increasing production lies in the possibilities of carrying out the smaller incidental operations in a more efficient manner, and the cumulative effect of savings of energy on these may well be substantial.

In the older foundries, I fear that much of our plant and buildings have outlived their usefulness and, apart from temporary expedients to tide us over the immediate future, we cannot expect to bring these works into a reasonable state of efficiency without substantial rebuilding and installation of more modern plants. Where rebuilding is part of our future plans there is a golden opportunity to depart from conventional ideas of foundry buildings. In this connection, we should not hesitate to use the services of lighting and colour experts. Drab, cheerless surroundings encourage mental depression and make the job seem more difficult. Because our principal moulding medium happens to be a dark coloured material there is every reason to nullify the effect of this by cheerful contrasting colours in the plant and buildings in which it is used.

With regard to the design of new foundry layouts, I feel that we ought to be sure that we are taking full advantage of the expert knowledge of the large suppliers of foundry plant. Even where modernisation can only be attempted on a piecemeal basis, a comprehensive scheme should be envisaged if costly mistakes are to be avoided.

On the subject of modernisation or re-equipment, economies can be effected in the more efficient use of the raw materials which are available. Much useful work was accomplished during the investigations of the Ironfounding Industry Fuel Committee, on which many of you served during the war period, resulting in a substantial saving in the use of coal and coke in many foundries. There is scope for still further improvements in this direction, which would materially assist in view of the present shortage of fuel and these improvements, in themselves, apart from the economy effected, would, to a very large extent, eliminate much of the fumes, smoke and dirt which are an objectionable feature in some of our foundries.

With all these things we shall fail without an adequate labour supply. The answer to this will, to some extent, depend on location, but I think it is true to say that no matter where the locality of a company may be, the problem is not likely to get easier; if anything, the reverse. The raising of the school-leaving age will make it more acute, followed by keener competition from all industry for the younger element. Various remedies have been put forward—labour from depressed areas, Italians, Poles, displaced persons—but for the most part none of these has any long-term stability. Italian foundry labour cannot be expected to solve any but a fraction of the difficulties and home sickness is likely to make it a short-term policy; of Poles it is too early to speak with adequate experience.

When one is short of labour, there are three inevitable remedies. First, one must try at all costs to hold what one has. Next, one must make sure that the labour force is being deployed in the best possible way, cutting out unskilled work for skilled men and practising the greatest dilution compatible with efficiency. It is, of course, much easier to dispose our labour to the best advantage in a fully mechanised plant, producing large quantities of a few types of castings only, but I suggest that the principles involved can, in some measure, be applied also to the smaller jobbing foundries.

Too often in smaller works we find that skilled labour is used for the performance of operations which can and should rightfully be carried out by less skilled labour. If the work performed in many of our works by skilled moulders were examined carefully, many of us would discover with surprise how few of his productive hours are actually spent in the application of his specialised knowledge. It is, I fear, the inclusion of so much unskilled and often heavy work in the daily working life of many of our skilled moulders which is partly responsible for the lack of new blood in our foundries.

Further, one must use the best job-placement methods. In my company, every job in our foundries has been made the subject of a job specification and, following medical assessment of the specification, every effort is made to obtain economical labour deployment, including a special effort to obtain maximum working potential from disabled persons. Such a system can be helped by adequate medical services which include pre-employment examinations. The object of this is not to turn labour away, but to place it effectively, and, where possible, remedy ailments that are capable of being remedied.

The third and last suggestion may sound obvious—it is to search for the reasons of the shortage of labour. Is it conditions or is it wages? I referred to a plea for a national wages policy in order to stabilise cost of production, and I am one of those who for a long time has supported the view that we must somehow tackle the relativity of wages. It is the value to the community of a service that must be assessed job by job and an increase in wages in one job, that leads to a sympathetic increase in another, defeats any planning by Government or industry to operate a regulated system of supply and demand. The food supply of this country has, for a long time, been planned for many goods in short supply by a system of points. I think that there could be—should be—some central wages co-ordination at national level, by the British Employers' Confederation, Trades Union Congress, Ministry of Labour and National Service, and the Board of Trade. I believe here is the most important measure we have to face and there is, fortunately, evidence that it is receiving attention. Our industry must be given an adequate voice and hearing in the deliberations, which can make such a scheme workable.

If we could agree on a wages structure for industry as a whole, each section could then turn to adequate recruitment methods—although handicapped to-day, I know, by housing accommodation. Following recruitment, I think then we come to the most important subject after wages—training for industry.

However far we may advance in foundry technique, and to whatever degree of mechanisation we may progress, there will still remain the need for the skilled craftsman, who, by his experience and knowledge, is able to overcome the problems presented to him at foundry-floor level. Our training programme must aim to interest and attract the future craftsman and equip him with a higher degree of skill. The foundry technician must learn to have the widest possible basis of knowledge and experience on which the future development of the industry can be built. In the case of the school-leaver, the transition from school life to industry is recognised as a difficult period in the life of the adolescent and recruits to the foundry industry should be helped during this period by a proper introduction to their future employment.

This introduction should give them a knowledge of the individual company, its products, processes and place in the industrial community, together with information on conditions of employment, safety and welfare. Many companies, having already recognised the importance of the foregoing, have provided fully-equipped training centres to include, for example, foundry, engineering and woodwork departments, each under the supervision of full-time instructors with wide experience in their respective branches of industry. The more ambitious of these have catered for theoretical training with perhaps a cinema and class-rooms equipped with film-strip projector, epidiascope and other visual aids to instruction and a technical library has been established to meet the needs of all apprentices and students.

To-day, visual aids play an important part in modern education and training. Films and filmstrips illustrating many branches of our industry are now available. The provision of clothes lockers and shower baths in such centres introduces the young worker to the conditions which one hopes will eventually prevail in all works. It is possible, too, as part of the curriculum of the training centre, to introduce expert physical training. The initial period in the training centre may vary in length, but usually, in the case of craft apprentices, is not less than four months. After a period in the works the boys return to the centre for two periods of one month during each of the two years following their entry to employment, to receive more specialised training for their particular trade.

My company has recently provided such a training centre, which members who visit Stanton will have an opportunity of inspecting. You will remember that I said some of the small units might have some doubts as to the practicability from their point of view of some of the suggestions that I would make. I referred, however, to the valuable co-operative work being done in several sections of industry to-day, and I feel that some sort of regional or district co-operative training centres should be considered and I whole-heartedly support the recommendations made in the reports issued some two or three years ago by the Education Committee of the Institute and the more recently issued report of the Recruitment and Labour Training Committee set up by the Council of Ironfoundry Associations which deal in detail with this subject.

An aspect of training that I have not covered above, but which I know you will agree is of equal importance, is the training of supervisory grades. At a previous Convention, I referred to the development of foremen's discussion groups. Such groups can be used not only as a medium to transmit board and top management policy to foremen, but to receive from foremen practicable suggestions for the improvement of company practice and the bettering of personal relationships within that company. Additionally, if a demand is created for foremanship courses, I am sure that there will be a ready response from the Ministry of Labour and National Service Regional authorities in providing such facilities in conjunction with educational institutions in the district. I know that not every foreman will obtain the same benefits from the facilities provided, but if it is responsible for fresh enthusiasms in a few, then the courses will not have been in vain and good material prepared for managerial appointments. It is a truism, which few here will dispute, that to the average employee the foreman is the company, and by the treatment that employees receive at his hands they will judge that company and its intentions towards them.

I think we must also review, critically, our employee services in an endeavour to reduce labour turnover and absenteeism and to increase the ratio of output to human effort. Like many of you here, I have had years of experience trying to provide sound welfare arrangements for employees. I know the disappointments that go with these efforts, particularly the abuse of bath-houses and lavatories and, in spite of such setbacks, we must not relax our efforts in this direction. Only by continued effort can we hope eventually to persuade our employees to treat these provisions with that same regard which they could reasonably be expected to exercise in the care of their own property.

If we are to bring our foundries to that state of efficiency which it is generally recognised is essential to ensure the complete recovery of our industry, then we must also improve the relations which exist between the employees and the managements. Some progress to this end has been made during recent years by the institution of works committees, but the scope of these cannot be other than limited. More progress to this end can be achieved by educating the workers to understand the proper functions of both management and workpeople and to endeavour to bring the latter to believe that the function of both is the same, namely, to provide a continually improving standard of living for all concerned in the industry. I feel that the quickest and, possibly, the only, way to accomplish this purpose, is to instill this ideal into the minds of the younger generation. It is too much to hope that we can, in a few short years, remove much of the distrust which still exists in the older classes between employee and management and we must, therefore, commence with the younger entrants to our industry.

Managements must take a genuine interest, not only in their bodily welfare, but also in their welfare as human beings. It is not enough merely to provide employees with amenities such as those to which I have already referred. If we restrict ourselves to this, we are doing little more than maintaining the employee in a fit state of health to carry out his duties. We must, in addition, do all in our power to foster a spirit of complete co-operation in business.

Since the employees are co-partners with the management in the fulfilment of the policy of any firm, it is not too much to ask that, so far as is reasonably possible, they should be made aware of this policy. We cannot expect the attainment of any object if one half of the team is unaware of the ultimate end to which their efforts are to be directed and the means to be adopted to gain this end. I believe that only in this way can we recreate something which, if it has not been entirely lost at the present time, is somewhat dormant, namely, the belief in the dignity of work of all classes. Every employee in each firm must have the opportunity to realise that, in their own sphere, his or her work is just as important in the scheme of things as that of a higher official. In this way we can hope that our employees will realise that their work will acquire a new social prestige, but the first approach to this end can only come from the managements.

In conclusion, I would emphasise the desirability of close co-operation between our Institute and the research associations allied to the foundry industry, particularly the British Cast Iron Research Association and the British Non-Ferrous Metals Research Association. During the last 20 years or more these research associations have grown in stature, have matured and become an important part of our industrial life. The Institute of British Foundrymen, which was established before either of them, to some extent paved the way for their inception and there is clearly room for all these organisations in the foundry industry. All have an unquestioned place in industry, serving their respective functions, which touch without overlapping; where one begins, the other ends. I suggest that it should be made clear to the industry as a whole that mutual co-operation is the policy which has the support and endorsement of the respective councils. It is already exercised in various ways, in such matters as specifications, foundry education, presentation of reports and papers and through committees studying matters of common interest. I hope to suggest during my term of office ways and means by which this co-operation can be fostered.

30-B.H.P. MARINE DIESEL ENGINE.

MESSRS. COVENTRY DIESEL ENGINES, LIMITED, COVENTRY.

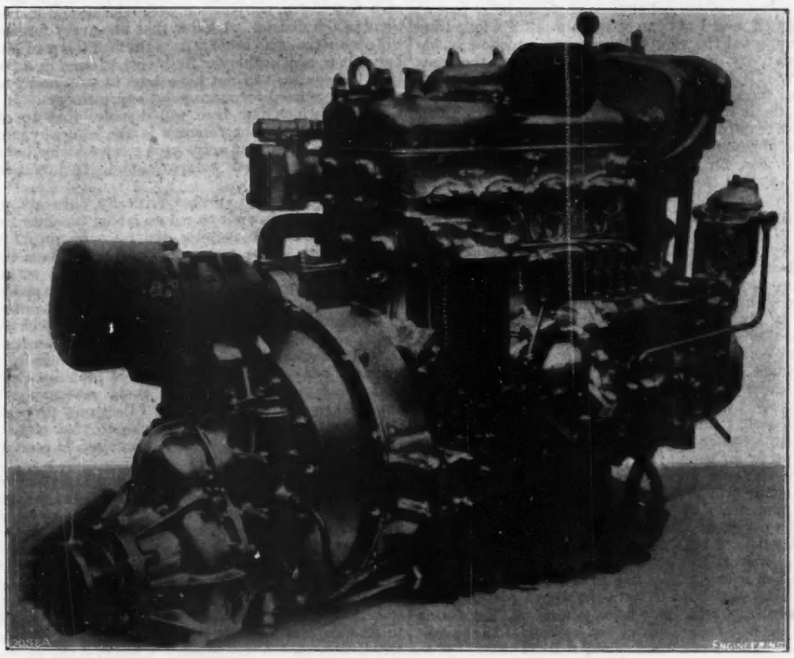


FIG. 1.

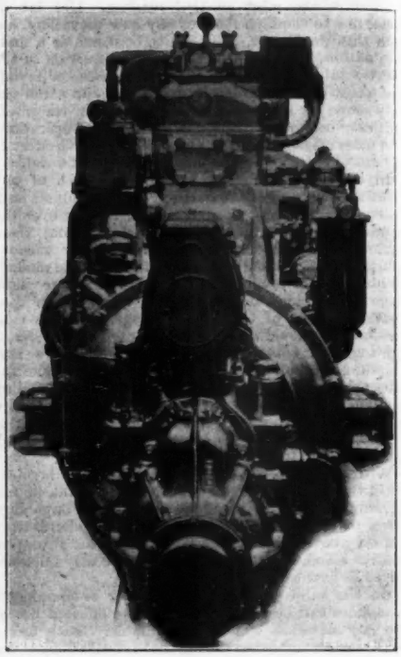


FIG. 2.

30-B.H.P. MARINE DIESEL ENGINE.

DURING the recent war, the activities of Messrs. Coventry Diesel Engines, Limited, Friars-road, Coventry, were confined to the manufacture of portable electric generating plant and fire pumps for the Services, and the development and production of special types of Diesel engines for the Navy. A large part of this equipment was based on the Godiva 30-h.p. marine engine which was designed before the war to replace the then popular 20- to 25-h.p. petrol engines. The Godiva engine, however, was developed considerably during the war, and the present-day product bears little resemblance to that in existence before the war. The latest example of this engine, which is known as the Godiva 30-h.p., type CD4, is illustrated in Figs. 1 and 2, on this page. It is a four-cylinder, four-stroke engine having a bore and stroke of 3·25 in. and 4·13 in., respectively, which gives a capacity of 137·1 cub. in. It produces 30 brake horse-power at the maximum governed speed of 2,000 r.p.m., and the fuel consumption is 0·38 pint per brake horse-power hour.

The cylinder block and crankcase are cast in one piece from a non-corrosive silicon-aluminium alloy which is protected further by anodising. The cylinder block is fitted with dry-type, cast-iron liners which are a push fit in the block, and the bores are plated with porous chrome. The detachable cylinder head is an iron casting and is fitted with vertical overhead valves operated in the usual way by push rods and rocking levers. The latter are fitted with Stellited pads on their working surfaces, and the valve gear is arranged so that the compression can be relieved on all four cylinders when starting. The combustion chambers are formed within the cylinder head; these are almost spherical in shape and arranged in two parts, the lower parts being integral with the cylinder head casting while the upper parts are detachable, being held in position by screwed plugs. The crankshaft is machined from a nickel-steel forging and is balanced both statically and dynamically. It is carried in five main bearings of the steel-backed, copper-lead type and is drilled for bottom-end lubrication. Solid-skirt aluminium-alloy pistons are used and each piston is fitted with three compression rings and one grooved-type oil-control ring, all the rings being located above the gudgeon pin. The connecting rods are machined from H-section, nickel-steel forgings and they are fitted with steel-backed, copper-lead bottom-end bearings, the top-end bearings being bronze bushes. The bottom ends are split diagonally, thus making it possible to withdraw the connecting rods through the bores of the cylinder liners, and in order to relieve the bottom-end bolts of shear stresses, the mating faces of the bottom ends are spigoted together.

The fuel-injection equipment consists of a standard C.A.V. injection pump, in which is incorporated a mechanical fuel-supply pump and hand-operated priming pump. The pump can be seen in Fig. 1, situated on the starboard side of the crankcase, and it is chain driven from the forward end of the crankshaft. The injectors are of the pintle type and they are kept cool by being housed in thin, non-ferrous alloy sleeves which pass through the water spaces An Iso-Speedic governor is fitted to the after end of the injection pump and this controls the engine revolutions throughout a speed range of 450 to 2,000 r.p.m., thus ensuring that, regardless of the speed or load, the engine does not race when the propeller leaves the water. The injection pump is arranged to deliver excess fuel for starting in the usual way, but in order to assist starting under exceptionally cold conditions, the engine is provided with primers. These are fitted into the air-inlet ports and the cap of each primer is designed so that it can be used to measure the priming fuel.

The electrical equipment includes a 12-volt dynamo and a 12-volt starter motor. The dynamo is located on the port side of the engine and, like the fuel-injection pump, is chain driven from the forward end of the crankshaft. It is fitted with a constant-voltage type regulator and is arranged to charge a 12-volt lead-acid type battery. The starter motor is located over the reverse gear and can be seen in position in Figs. 1 and 2. It is of the axial engagement type and is fitted with a built-in solenoid relay switch. A hand-starting gear also is fitted and this is arranged to give a ratio of two turns of the handle to three of the crankshaft. In order to provide maximum purchase, the handle is raised to the level of the cylinder head and the chain which connects it to the crankshaft is fully enclosed.

With the exception of the top ends, the engine bearings are supplied with oil under pressure from a gear-type pump driven from the camshaft by skew gears. A renewable-type cartridge oil filter is fitted into the pressure system and this is located at a convenient height for purposes of inspection and renewal. The sump has a capacity of 2½ gallons and it is fitted with a hand-operated draining pump. Apart from the exhaust manifold, the engine is cooled by a closed-circuit fresh-water system. The heat exchangers are incorporated in the sump, which is cast so that longitudinal channels are formed externally along each side. A cover is bolted over each channel, a corrugated-copper plate being interposed between the cover and the sump so that two shallow rectangular passages are formed and the fresh water is circulated along the passage adjacent the sump on each side, while the sea water is circulated through the two outer passages. By adopting this arrangement, the oil in the sump is heated during the early stages of running and subsequently is kept at an even temperature. The fresh water is circulated by a centrifugal pump and the sea water by a gear-type pump fitted with bronze gears, the sea water serving to cool the exhaust manifold also; both pumps are driven by an extension from the dynamo armature shaft. The cover for the starboard heat exchanger, together with the connecting pipes, can be seen in Fig. 1, while the fresh-water circulating pump can be seen to the left of Fig. 2.

The standard engine is fitted with an epicyclic reverse gear selected by two oil-operated fabric-lined self-adjusting clutches, the reverse-gear housing being bolted directly to the flywheel housing. Oil under pressure, both for operation of the clutches and for lubrication purposes, is supplied by an engine-driven pump, which is separate from the engine lubrication system and fitted with its own filter and pressure-relief valve. In both ahead and astern positions, the shaft-to-engine speed ratio is 1 to 1. Although not fitted as standard, reduction gears giving ratios of either 2 to 1 or 3 to 1 are available. The reduction-gear housing is bolted directly to the reverse-gear housing, thus forming a single unit, and the engine illustrated is so fitted. The size of both reduction-gear units is identical and they are fitted with single-helical gears, lubricated from the reverse-gear oil system, and a propeller-shaft thrust bearing is incorporated within each unit.

The equipment supplied with the engine is exceptionally complete, and includes a revolution counter, engine-oil pressure gauge, reverse-gear oil pressure gauge, engine-coolant temperature gauge, ammeter, and 12-volt lead-acid battery. The weight of the engine, when fitted with reduction gearing, is 930 lb., while the overall length, width, and height are 41⅛ in., 25⅛ in. and 36½ in., respectively. Without reduction gearing, the overall length is shortened to 40¼ in., and the weight is reduced to 885 lb. It will be appreciated from these figures that the engine is of compact design, but even so, accessibility has not been overlooked, which, generally, is quite satisfactory.

TRENDS IN REINFORCED CONCRETE.—The Reinforced Concrete Association, York Mansion, 94, Petty France, London, S.W.1, are arranging a symposium on "Trends in Reinforced Concrete," which will be held in October next. The whole field of reinforced-concrete utilisation, design, construction, materials and plant will be covered, and short contributions, which will not take more than ten minutes to read, are invited. To avoid duplication, intending authors should, however, submit a note of the subject with which they propose to deal to the Association before Thursday, July 31.

PORTABLE ELECTRIC DRILLS FOR COAL.

MESSRS. CONSOLIDATED PNEUMATIC TOOL COMPANY, LIMITED, LONDON.

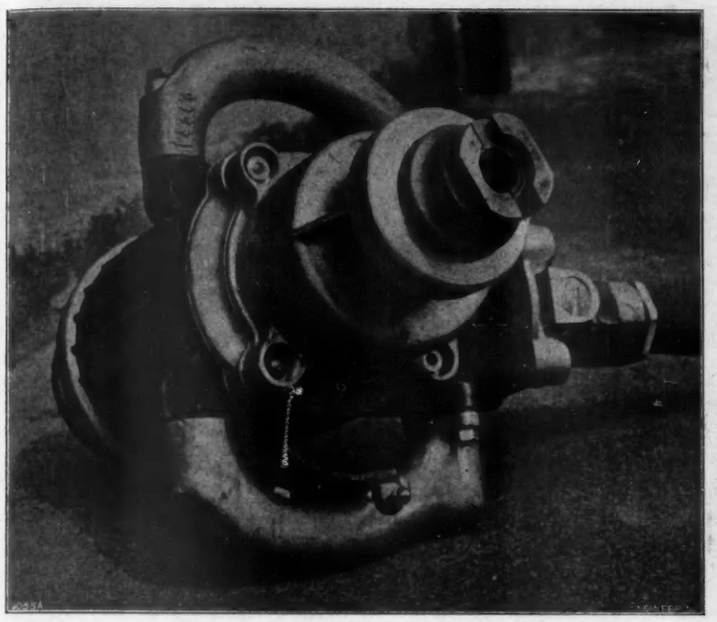


FIG. 1. 50-CYCLE DRILL.

FIG. 2. 150-CYCLE DRILL.

PORTABLE ELECTRIC DRILLS FOR COAL.

THE two compact portable electric drills for coal illustrated in Figs. 1 and 2, above, although bearing a superficial resemblance, are of different construction internally. The drills are now being manufactured by Messrs. Consolidated Pneumatic Tool Company, Limited, 232, Dawes-road, London, S.W.6. The drill shown in Fig. 1 is fitted with a motor having a standard winding for 125 volt, three-phase, 50-cycle current, and of the straightforward induction type. The motor is rated at 1·5 h.p. on a ½-hour basis, to British Standard Specification No. 1090-1943. It is made in four models having speeds of 700 r.p.m., 534 r.p.m., 417 r.p.m., and 319 r.p.m., respectively. In the design of a coal drill it is necessary, of course, to pay special attention to safety and, in consequence, the drill has been tested and certified by the Mines Research Station at Buxton, and is covered by Flameproof Certificate No. FLP 2018. The motor must also have ample power in order to prevent stalling when the bit encounters hard material. Moreover, the tool must be as light as possible, consistent with rough usage, so that Elektron castings, heat-treated to give maximum tensile strength, are employed.

The motor has a solid cast-type "Uniloy" rotor, free from end connections, and carrying a pinion which drives, through gearing, the main gearcase spindle; the latter carries the wing driver for the bit at its free end. This layshaft arrangement, in which heat-treated alloy-steel spur wheels are employed, gives the highest bit speed of 700 r.p.m., This model is fitted with a single-reduction gear, but the other three standard models have double-reduction gears. The double-reduction gears naturally cause a slight increase in weight, which is 38 lb. for the three lower speed models and 36 lb. for the high-speed one. The weight/power ratio is low, being from 24 lb. to 26 lb. per horse-power developed, according to the particular model. The gearbox, it will be seen, can be detached from the body of the tool by unscrewing four shrouded nuts with a box spanner, thus simplifying maintenance, while the degree of interchangeability provided enables gearboxes of different standard ratios to be substituted should a change of speed be required. Other speed ratios can be supplied if required.

The front end of the gearcase is sealed to prevent coal dust from working along the spindle into the gears. The wing driver is shrouded, in accordance with the requirements of the Chief Inspector of Mines, but, alternatively, a fitting can be supplied which not only provides this shrouding but facilitates the supporting of the tool by hand when starting a hole. The fitting has an external sleeving for gripping, the sleeve being free to rotate with the extension spindle when it is not being held. The main casing of the tool is formed with deep fins, over which air is directed by a fan. The fan cover is finished with a plate having a smooth surface, so that the operator can apply pressure with his shoulder. Unlike most pneumatic tools, the handles are not integral with the body, so that if one is broken it can be replaced by removing the nut of a through bolt. Heat-insulating pads between the handle and the body keep the handles cool. The internal bearings are set in hard-metal inserts cast integral with the body. The rotor bearings are initially packed with grease and are sealed on one end to prevent leakage into the rotor. The grease is supplied through two plugs.

The drill is operated on the usual remote-control system, in which a single-pole switch closes the main contactor situated in the gate-end panel. The trailing cable is coupled to the motor by a plug and socket connection. The direction of rotation can be reversed by removing the four nuts securing the cable entry flange and turning it through 180 deg., this adjustment resulting in changing over the phases. Since operators not infrequently drag the drill to a fresh position by means of the cable, care has been taken to design a particularly strong gland for the cable attachment. The switch in the body has large renewable contacts and has a positive action. The spring-loaded trigger can be seen on one of the handles in Fig. 1; release of pressure on it results in opening the switch. Both trigger and switch mechanism are sealed against the entry of coal dust. The position of the spindle is such that holes may be centred within 2 in. of the roof.

The drill shown in Fig. 2 incorporates all the features of that shown in Fig. 1, but has a squirrel-cage induction motor operating on a three-phase supply at 150 cycles and 110 volts, and running at 9,000 r.p.m. The tool is available in two models, which have drill speeds of 680 r.p.m. and 440 r.p.m., respectively. The motor develops 2 h.p., and the tool weighs 35 lb., giving a weight/power ratio of 17·5 lb. per horse-power. It is thus eminently suitable for drilling Cardox or burster holes, and also for water-infusion holes, in addition to ordinary shot holes. The 50-cycle drill normally operates from a gate-end panel containing a transformer, but the 150-cycle drill also requires a frequency changer.

INCREASED PRICES FOR ROPE AND TWINE.—The Central Price Regulation Committee announce that, from July 1, the manufacturers' prices of all rope and twine containing sisal—other than binder twine—will be increased by 18l. 10s. a ton. This follows an increase in the price of sisal.

INFRA-RED HEATING IN INDUSTRY.

AN exhibition demonstrating some of the applications of infra-red heating in industry has been organised by the British Gas Council and was opened, at Gas Industry House, 1, Grosvenor-place, London, S.W.1, on Thursday, June 19, by Mr. W. Leonard, Joint Parliamentary Secretary of the Ministry of Supply. The main object of this exhibition, which will remain open at least until the end of July and probably longer, is to show how the time necessary for drying protective paints, ceramics and plastic materials can be reduced by the use of infra-red heat generated by gas burners. For almost all normal drying processes, and particularly metal finishing processes, a temperature not exceeding 650 deg. F. is adequate; and two types of oven operating in this range are being exhibited.

One of these is the infra-red tunnel made by Messrs. Neil and Spencer, Limited, Effingham, Surrey. This consists essentially of a row of non-Bunsen burners, which fire into a chamber that is bounded on the outer side by insulation and on the inner side by a mild-steel black panel. Even heat distribution in the chamber is ensured by an inner sheet, which is attached to the lower half of the radiating panel. The chamber is semi-cylindrical in section, 3 ft. or 4 ft. long and 2 ft., 3 ft. or 4 ft. in diameter; and a number of sections can be joined to form a tunnel through which a conveyor carries the articles to be dried. The second type of heater was manufactured by the "Ray-Heet" ing Company, Limited, Rayleigh Works, Station-road, Leatherhead, and is fitted with burners supplied by Messrs. Thomas Potterton (Heating Engineers) Limited, 20, Buckhold-road, Wandsworth, London, S.W.18. In this the panels are flat, and each unit is individually heated and controlled; and can be assembled in a variety of ways, depending on the type of article to be dried.

In both cases the paint absorbs the long-wave radiation and is polymerised by the local rise in temperature without the main bulk of the article having to be raised to the full temperature. As examples of the saving in time effected by the use of infra-red heating, it is claimed that the large metal sheets which are used for prefabricated houses can be dried after painting in 2½ minutes, while with normal methods as much as 8 hours are required. The process is also applicable in the pottery industry where the period of six to twelve days necessary when air drying is used can be reduced to minutes. The drying time for the synthetic glue employed in making the laminated timber can also be cut down substantially; and infra-red heating has been applied experimentally to the drying of bank notes where both the paper and ink must be dried without injury.

INSTITUTION ELECTIONS.

INSTITUTION OF CIVIL ENGINEERS.

Student to Associate Member.—Hugh McMillan Alexander, Lagos, Nigeria; Ronald William Allport, Cradley, near Malvern; Ronald Ewart Annetts, Hastings; Richard Henry Arnold, Temple Ewell, near Dover; David Ronald Bailey, B.Sc. Tech. (Manch.), Manchester, 16; William Gilbert Bald, B.Sc. (St. Andrews), Dundee; Eric Eugene Bruce Barton, Ipswich; Niall Trevor Blunden, B.E. (Nat'l.), Dublin; Peter Graham Boosie, B.Sc. (B'ham), Birmingham; Raymond Percy Brownjohn, Canterbury; Richard Stuart Burns, M.Sc. (Witwatersrand), Somerset West, S. Africa; John Carson, B.Sc. (Glas.), Coatbridge, Lanarkshire; Cyril Donald Cooper, Northampton; Philip Morgan Crossley, Padiham, near Burnley; Donald Edward Dobson, Looe, Cornwall; John Eric Glass Donohoe, Glasgow, E.1; Leslie Ewart Ellis, Darlaston, Staffs.; John Christopher Harold Finlinson, Winchester; Edward Court Fisher, Liverpool; Ernest Reginald Ford, Cardiff; Robert Tennant Foulds, Coatbridge, Lanarkshire; Bernard Frederick Fox, B.Sc. (Leeds), Bradford; Maurice Samuel Frances, B.Sc. (Eng.) (Lond.), London, N.W.2; Cecil Jack Freeman, B.Sc. (Cape Town), Cape Town, S. Africa; Reginald James Green, Eana Barrage, near Luxor, Upper Egypt; Raymond Gordon Rider Haggard, Wallington, Surrey; Peter Charles Gerald Isaac, B.Sc. (Eng.) (Lond.), Newcastle-upon-Tyne; Frank James Johnson, London, S.W.16; James Bernard Kuipers, Chepstow, Mon.; David Cameron Lindsay, B.Sc. (Glas.), Millport, Isle of Cumbrae, Buteshire; Sue-Leong Low, M.A. (Cantab.), Rugby; William Trevor Luke, B.Sc. (Eng.) (Lond.), Blackwood, Mon.; Amos Ronald Fairlie McGahan, Kingston, Jamaica, B.W.I.; James Kenneth McIntyre, B.Sc. (Durham), Durham; John Charles Middlehurst, B.Sc. (Eng.) (Lond.), Penarth, Glam.; Neil John Miller, Gore, N.Z.; Walter Ernest Miller, Capel, Surrey; Philip John Millman, Lydford, Devon; John Edward Myatt, Birmingham; Denis Edmund Nash, Northwood, Middx.; Nanda Nimalasuriya, B.Sc. (Eng.) (Lond.), Colombo, Ceylon; Eric Ernest Oakes, Oxford; David Dure Paterson, Johnstone, Renfrewshire; Reginald Hugh Prince, Cromer; John Leonard Mitchell Ransford, B.Sc. (Eng.) (Lond.), London, N.6; David Temple Robinson, Wallington, Surrey.

LAUNCHES AND TRIAL TRIPS.

MOTORSHIP.—Diesel-engined vessel built by Messrs. A. and J. Inglis, Limited, Glasgow, for the Irrawaddy Flotilla Company, Limited. Gross tonnage, 100. Launch, June 25.

M.S. "ENGLAND."—Single-screw cargo vessel, built by the Caledon Shipbuilding and Engineering Company, Limited, Dundee, for the Currie Line, Limited, Leith. Main dimensions: 335 ft. overall by 46 ft. by 28 ft. to shelter deck; deadweight capacity, 3,560 tons. Six-cylinder four-stroke B. and W. type oil engine of 2,000 brake horse-power, supplied by Messrs. John G. Kincaid and Company, Limited, Greenock, to give a service speed of 12 knots. Trial trip, June 26.

M.S. "HARTISMERE."—Single-screw cargo vessel built and engined by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, to the order of Messrs. J. and C. Harrison, Limited, London. Main dimensions: 460 ft. 6 in. overall by 59 ft. 6 in. by 28 ft. 8 in.; deadweight capacity, 9,800 tons. Opposed-piston four-cylinder oil engine to give a service speed of 13 knots. Trial trip, June 30.

M.S. "RIO SEGUNDO."—Single-screw grain and general cargo vessel, built by the Burntisland Shipbuilding Company, Limited, Burntisland, for the Argentine State Shipping Company (Flota Mercante del Estado), Buenos Aires. Main dimensions: 425 ft. by 57 ft. by 37 ft. 9 in. to shelter deck; deadweight capacity about 9,400 tons on a draught of 25 ft. 10 in. Four-cylinder Doxford-type opposed-piston two-cycle Diesel engine of 3,300 brake horse-power, supplied by the North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne. Launch, July 2.

M.S. "BRITISH FERN."—Single-screw tanker built by Messrs. Sir James Laing and Sons, Limited, Deptford Yard, Sunderland, for the British Tanker Company, Limited, London. Main dimensions: 463 ft. 5½ in. by 61 ft. 9 in. by 34 ft. 1 in.; deadweight capacity, 12,250 tons on a draught of 27 ft. 7 in. Four-cylinder opposed-piston oil engine supplied by Messrs. William Doxford and Sons, Limited, Sunderland, to give a service speed of 11½ knots. Trial trip, July 2.

M.S. "MORBIHAN."—Single-screw general cargo vessel, built and engined by Messrs. Harland and Wolff, Limited, Govan Shipyard, Glasgow, to the order of the French Government for the Compagnie Delmas Vieljeux. Main dimensions: 395 ft. by 55 ft. by 33 ft. 6 in. to shelter deck; gross tonnage, about 4,450. Harland-B. and W. ten-cylinder two-stroke Diesel engine. Trial trip, July 2.

BOOKS RECEIVED.

Department of Scientific and Industrial Research. Fuel Research. Technical Paper No. 49. *The Characteristics of Pulverised Coal. Effect of Type of Mill and Kind of Coal.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 3*d.* net.]

University of Toronto Engineering Society. Transactions and Year Book, 1947. The Secretary, The Engineering Society, University of Toronto, Toronto, Ont., Canada.

Mitteilungen aus dem Institut für Baustatik an der Eidgenössischen Technischen Hochschule in Zürich. No. 20. *Stabilität der Platten im plastischen Bereich.* By DR. SC. TECHN. C. F. KOLLBRUNNER and G. HERRMANN. A.-G. Gebr. Leemann & Co., Stockerstasse 64, Zürich 2. [Price 12 Swiss francs.]

Ministry of Supply. Directorate of Royal Ordnance Factories (Explosives). Industrial Experimentation. Second edition. By K. A. BROWNLEE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* 6*d.* net.]

"Mechanical World" Monographs. No. 38. *Engineering Statistics.* By G. W. STUBBINGS. Emmott and Company, Limited, 31, King-street West, Manchester 3. [Price 2*s.* net.]

Machine Shop Operation. Volume 3. *Shaper Operations.* By LEWIS E. KING. The Macmillan Company, 60-62, Fifth-avenue, New York City, U.S.A. [Price 1 dol.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 5*s.*]

Practical Book-Keeping and Costing: An Introduction for Commercial and Technical Students. By F. A. GORDON and W. WADE. Part I. [Price 6*s.* 6*d.* net]. Part II. [Price 6*s.* 6*d.* net.] Part III. [Price 7*s.* 6*d.* net.] Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2.

Air Conditioning and Elements of Refrigeration. By SAMUEL P. BROWN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 6 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30*s.*]

Materials of Industry: Their Distribution and Production. By the late SAMUEL FOSTER MERSEREAU. Fourth edition. Revised by PROFESSORS CALVIN G. REEN and KENNETH L. HOLDERMAN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 2·80 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 14*s.*]

The British Corporation Register of Shipping and Aircraft. Rules for the Construction and Classification of Steel Ships and of Ships' Machinery. Offices of the Corporation, 14, Blythswood-square, Glasgow C.2. [Price 30*s.*]

Electricity and Fire Risk. By E. S. HODGES. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 15*s.* net.]

Thorpe's Dictionary of Applied Chemistry. Fourth edition revised and enlarged. Volume VIII. *Methal to Oils, Essential.* DR. M. A. WHITELEY, Editor. Longmans, Green and Company, Limited, 43, Albert-drive, Wandsworth, London, S.W.19. [Price 80*s.* net.]

Engineering Industries Association. Export: A Handbook of Procedure. Offices of the Association, 9, Seymour-street, London, W.1. [Price 3*s.* 6*d.*, post free.]

Mitteilungen über Forschung und Konstruktion im Stahlbau. No. 5. *Stählerne ausbetonierte Trogbrücken der S.B.B. mit durchgehendem Schotterbett. Vedeggiobrücke und Trodobachbrücke.* By ING. DR. SC. TECHN. CURT F. KOLLBRUNNER and OTTO WICHSER. A.-G. GEBR. LEEMANN & Co., Stockerstrasse 64, Zürich 2. [Price 4 Swiss francs.]

Mitteilungen der Versuchsanstalt für Wasserbau und Erdbau an der Eidgenössischen Technischen Hochschule in Zürich. No. 11. *Der Triazialapparat. Ein Instrument der Boden- und Eismechanik zur Prüfung von Verformungs- und Bruchzuständen.* By R. HAEFELI and CH. SCHAERER. *Die Anwendung der Elektrizität zur Entwässerung und Verbesserung feinkörniger Bodenarten.* By W. SCHAAD and R. HAEFELI. [Price 5·70 Swiss francs.] No. 12. *Umbau der Landquartbrücke der Rhätischen Bahn in Klosters.* By C. MOHR and others. A.-G. Gebr. Leemann & Co., Stockerstrasse 64, Zürich 2.

Swedish Cement and Concrete Research Institute at the Royal Institute of Technology, Stockholm. Bulletin No. 7. *Temperature Buckling of Cylindrical Steel Shells Surrounded by Concrete.* By STEN G. A. BERGMAN. With summary in English. Svenska Forskningsinstitutet för Cement och Betong vid Kungl. Tekniska Högskolan i Stockholm. [Price kr. 2.]

Ministry of Transport. Railways Division. Railway Accidents. Report on the Derailment Which Occurred on the 27th December, 1946, at Byfleet on the Southern Railway. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

Wellington Harbour Board, New Zealand. Statement of Accounts with Annual Reports and Other Statistics for the Period Ended 30th September, 1946. The Secretary, Wellington Harbour Board, Wellington, New Zealand.

PERSONAL.

SIR JOHN ANDERSON, F.R.S., chairman of the Atomic Energy Committee, has been awarded the honorary degree of Doctor of Laws by the University of Sheffield. The honorary degree of Doctor of Engineering has been conferred upon SIR DONALD BAILEY, the inventor of the Bailey bridge.

DR. OTTO ROBERT FRISCH, Director of the Nuclear Physics Section of the Atomic Energy Research Establishment at Harwell, and newly-appointed Jacksonian Professor of Natural History at the University of Cambridge, has received the honorary degree of Doctor of Science from the University of Birmingham.

SIR MAURICE SIMPSON, C.S.I., M.I.E.E., and MR. JOHN LAMONT have resigned from the board of Messrs. W. T. Henley's Telegraph Works Company, Limited, as from June 30. MR. F. W. M. ANDERSON, general manager of the firm, and MR. A. H. M. JACOB, secretary, have been appointed directors as from July 1. MR. E. THORNLEY, manager of the Birmingham branch of the company, retired on June 30 after 35 years' service. His successor is MR. F. C. HORSFORD, Assoc.I.E.E.

MR. COLIN BARTLETT, O.B.E., B.Sc., assistant to the Chief Ship Surveyor, Lloyd's Register of Shipping, has been made Deputy Chief Surveyor (Administration). MR. W. J. FERGUSON, M.Eng., principal surveyor on the Chief Engineer Surveyor's staff, has been made Assistant Chief Engineer Surveyor. MR. J. HODGSON, principal surveyor for the Middlesbrough and Hartlepool districts, has been appointed a principal surveyor on the Chief Ship Surveyor's staff. MR. H. R. HOWELLS, senior surveyor at Manchester, has been made principal surveyor for refrigeration on the Chief Engineer Surveyor's staff; and MR. H. N. PEMBERTON, a senior engineer surveyor, has been appointed a principal surveyor on the Chief Engineer Surveyor's staff.

SIR FREDERICK LEGGETT, C.B., has been appointed chairman of the London and South Eastern Regional Board for Industry.

MR. H. NIMMO, M.I.C.E., M.I.Mech.E., M.I.E.E., has agreed to serve as President of the Association of Supervising Electrical Engineers for a second year. He will deliver his second presidential address on October 14.

MR. T. R. BECKETT, who has been in the Nigerian Civil Service since 1924, has been made Assistant Engineer-in-Chief in the Posts and Telegraphs Department of Nigeria. MR. E. W. M. REVELL, who has been in the Nigerian Civil Service since 1928, has been appointed divisional engineer in the same department.

MR. E. W. COLBECK, M.A. (Cantab.), has now taken up his appointment as metallurgical and research director to Messrs. Hadfields Limited, East Hecla Works, Sheffield, with effect from July 1.

MR. G. V. BLOOMFIELD, B.Sc., has been appointed research physicist in the works of the Hymatic Engineering Company, Limited, Redditch, Worcestershire. He will be engaged primarily on research into the mechanism of drop formation, with particular reference to spraying fluids and also on work concerning the spraying of powders.

MR. P. W. D. WINKLEY, formerly sales-office manager at the head office of Macrome Limited, Aldersley, Wolverhampton, has been appointed branch manager at the firm's Manchester office, 241, Deansgate.

MR. R. G. STANDERWICK, chief engineer of the aircraft gas-turbine engineering division of the General Electric Company, New York, U.S.A., retired on July 10.

DR. W. J. WARBOYS, chairman of the board of the Plastics Division, Imperial Chemical Industries, Limited, has been appointed an additional member of the Council of Industrial Design.

The Board of Trade have appointed MR. F. S. TREDINNICK to be Registrar of Companies in place of MR. P. MARTIN, who has retired.

A new company, ACHESON COLLOIDS LIMITED, has been registered to take over the business of E. G. ACHESON LIMITED. The change is due to technical reasons only, the management, staff and address, namely, 9, Gayfere-street, London, S.W.1, remain unaltered.

THE GLACIER METAL COMPANY, LIMITED, Alperton, Wembley, Middlesex, announce that their newly-built Scottish factory, at Kirkstile, Kilmarnock, was formally opened on June 16. It employs nearly 500 persons in the manufacture of plain bearings and bushes.

COURSES IN ILLUMINATING ENGINEERING.—The Illuminating Engineering Society, 32, Victoria-street, London, S.W.1, have arranged courses for candidates for the City and Guilds of London Institute intermediate examination in illuminating engineering. These courses will take place between September, 1947, and May, 1948, at the Northampton and Borough Polytechnics, in London, and at the Central Technical College, Birmingham. Entrants should communicate directly with these institutions. It is hoped to arrange similar courses at Cardiff, Leeds, Liverpool and Manchester.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Outputs are still at approximately full capacity, but the market demand for steel shows little sign of being satisfied. Makers have nine months work on hand, and prospective buyers are beginning to allow orders to taper off owing to the prolonged delay in bringing forward fresh supplies, together with the uncertainty as to the future economic position. Plates and sections are being eagerly taken up, but the quantities are so limited that the users' stocks are being rapidly exhausted. This applies particularly to the shipbuilding and allied industries. Re-rollers are still confined to about three days' work per week for lack of semies, and there is a report that no purchases of American semies have been effected yet, and little likelihood of any appreciable tonnage being obtained from this source. The demand for sheets is perhaps heaviest of all, and users are only getting part delivery of their requirements. New business is a matter of negotiation, and high-priority specifications absorb the bulk of supplies.

Scottish Coal.—There has been no appreciable progress in reducing the leeway in output arising from the introduction of the shorter working week. In Scotland, the loss amounts to roughly 35,000 tons a week, which is just half the tonnage that was formerly won on a working Saturday in this district. If this tonnage loss remains constant for any length of time, the Scottish programme of replenishment for the remainder of the summer and autumn months will almost certainly be crippled, and already public-utility consumers are facing the probability of having to dip into their long-term stocks to eke out the temporary loss of supply arising from the Fair Holidays a week hence. Industry is receiving sufficient fuel to meet all current requirements, but here again, the replenishment prospect is rather gloomy. The general opinion of the market is that the winter stock target will be missed by at least 500,000 tons of coal, despite the total cessation of exports and the virtual elimination of coal movements from Scotland to England. Scotland's Ulster commitments have also been lightened to the extent of some 15,000 tons a week. Unless the Coal Board can reach agreement with the local union on the re-allocation of tasks underground, it will be practically impossible to reduce the weekly loss of output below the 30,000-ton mark within the next six months. The feeling that the union is not capable of inducing its members to accept any general increase in task is supported by the depressed output returns of the collieries. Greater development is required to make most of the pits capable of operating additional faces, but a deeper under-cut would have solved the under-production problem more quickly than any other method if both sides had full liberty of action to make the necessary mechanical adjustments.

THE PROFESSIONAL ENGINEERS APPOINTMENTS BUREAU.—In order to obviate any possibility of its name being infringed, the Professional Engineers Appointments Bureau has been incorporated as a company under limited guarantee. The scope of the Bureau remains unaltered, and persons who, by reason of their engineering qualifications, belong to the Institution of Civil Engineers, the Institution of Mechanical Engineers, or the Institution of Electrical Engineers, or persons whose engineering qualifications for election or admission to one of those bodies have been approved by the respective councils, are invited to register. The necessary forms may be obtained on application to the Registrar of the Bureau, 13, Victoria-street, Westminster, S.W.1. A stamped addressed foolscap envelope should be enclosed. Employers of professional engineers are invited to submit concise details of positions vacant on their staff, indicating any special requirements, and stating the salary range offered.

INTERNATIONAL STANDARDISATION ORGANISATION.—The first meeting of the Council of the International Organisation for Standardisation (known as the I.S.O.) since the ratification of its constitution, drafted in London last October at a meeting of 28 nations, was held in Zürich from June 17 to 20. The Council consists of the national standards bodies of Australia, Belgium, Brazil, China, France, India, Norway, Switzerland, the United Kingdom, the United States, and the U.S.S.R. The Council appointed Mr. Henri St. Leger to be general secretary and his office will be situated in Geneva. The meetings were presided over by Mr. Howard Coonley, of the United States, who was elected President of the I.S.O. in London last October. An extensive programme of technical work will be submitted for consideration to the standards organisations of the different countries. The International Electrotechnical Commission (I.E.C.) also held a meeting of their council under the chairmanship of the President, Mr. Emile Uytborck, of Belgium. As a result of a joint meeting between the I.E.C. and the I.S.O., it was agreed to recommend to the constituent members of the I.E.C. that this body should affiliate with the I.S.O.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Of some interest on the Welsh steam-coal market during the past week was an inquiry for a ship, of between 2,500 and 5,000 tons, to lift a cargo of Polish coal from Gydnia or Gdansk during the second half of the present month for delivery to the United Kingdom. From this it would seem that details have now been completed under the Anglo-Polish trade agreement. It was announced by the leader of the Polish delegation in London last month, that Poland would send Great Britain 250,000 tons of coal during the next twelve months. It will be remembered that inquiries were circulating recently for ships to lift American coal for delivery to this country, beginning this month. Trading conditions were very difficult on the Welsh steam-coal market last week. Home requirements provided a steady outlet for all the current productions. The high-priority industries and public-utility undertakings made heavy demands and there was no indication of any falling off in the requirements of these users for some time to come. Industrial users were anxious to obtain considerable supplies, both to meet their current needs and for stocking purposes. As a result, there was no coal available for export, although a number of overseas users showed a sustained interest. Practically the only shipments made were small quantities of some of the very poorest coals, which were destined for Eire. In addition, some good quality anthracites were made available for delivery to Canada. Bunker coals were in steady request, while patent fuel and cokes remained well booked ahead and were in good demand.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, the strong demand for tin-plates was fully maintained and a satisfactory volume of business transacted with both home and overseas consumers for delivery during the present third quarter of the year. The orders on makers' books, in the aggregate, are much in excess of what they were on the corresponding date last year. In the export market, the sales continued satisfactory and formed a good proportion of the total business conducted in tin-plates during the week. Steel sheets are still in great request, and as production is inadequate, arrears in deliveries are accumulating.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The demand for iron and steel is still much greater than producers can meet, and little material is obtainable from abroad. The fuel shortage is seriously reducing the output of nearly all commodities, and conditions do not encourage the hope of much expansion of output in the near future. Complaints of scarcity of pig iron are increasing. Adequate parcels of native ironstone and imported ores are reaching the blast-furnaces but scarcity of coke is still acute. Little heed is taken of the flat-rate increase in railwaymen's wages. The event, of course, gives another inflationary turn which will be translated into higher prices for iron and steel, but there is no scope for speculative buyers to beat the market by making anticipatory purchases. All commodities are strictly rationed and outputs are taken up readily as they become distributable.

Foundry and Basic Iron.—The supply of foundry pig-iron is insufficient for current needs. There is no make of local brands and delivery licences for the outputs of other iron areas are difficult to secure. Even when authorisation for supply is issued, the iron is not always obtainable. An early curtailment of the distributable tonnage is regarded as likely, as foundry blast-furnaces may be switched over to the making of basic iron. The whole of the basic iron output is retained for the needs of the adjacent steel-producing plants.

Hematite, Low-Phosphorus and Refined Iron.—The limited make of East Coast hematite is moving promptly into use and consumers would welcome larger deliveries. Low-phosphorus iron is scarce and in consequence there is stronger demand for hematite and refined iron. Outputs of refined qualities are readily taken up.

Manufactured Iron and Steel.—Manufacturers of semi-finished iron are readily disposing of their outputs, and steel semies, which are somewhat less scarce, are still wanted in much larger quantities than are obtainable. Re-rollers are very short of billets, blooms and sheet bars. In the finished branches of industry, plate makers are fully sold to the end of the year and sheet producers cannot cope with the demand for black and galvanised sheets, contracts for which extend as far ahead as can be accepted. Joist and section makers have a great deal of work in hand and customers are anxiously seeking deliveries.

Scrap.—All available parcels of iron and steel scrap are readily taken up.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF PHYSICS.—*Industrial Radiology Group:* Friday and Saturday, July 18 and 19, Electric Lamp Manufacturers' Association, 2, Savoy-hill, Strand, W.C.2. Symposium on "Methods of Crack Detection." Friday, July 18, 10 a.m., (i) Introductory Address, by Dr. W. Betteridge. (ii) "Radiological Methods," by Mr. C. Croxson. (iii) "Visual, Etching and Magnetic Methods," by Mr. P. Rowbotham. 3 p.m., various works' visits. Saturday, July 19, 9.30 a.m., Annual General Meeting for Members only. 10 a.m., (i) "Eddy-Current Methods," by Mr. A. M. Armour. (ii) "Crack Detection by Supersonic Methods," by Mr. D. O. Sproule.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The flow of coke to the blast-furnaces has been rather more regular and has reduced the anxieties in regard to pig-iron production. Steel production still falls short of the requirements of the mills, tilts and forges, and is likely to be reduced by the refusal of four branches in South Yorkshire of the Iron and Steel Trades Confederation to operate the agreement reached between the Confederation and steel firms for bridging the gap in steel production and heat-treatment occasioned by the operation of the shorter working week. The branches have been given 21 days to reconsider their decision, and have refused again to accede to the agreement. The Confederation has therefore decided to disband the four South Yorkshire branches concerned and to give each member an opportunity to record his vote on the matter. Those who accept the agreement will be retained as members of their union, and the remainder will be expelled. About 1,500 men are affected at the works of the United Steel Companies and the Park Gate Iron and Steel Company. Pressure is being exerted to accelerate the production of coal-mining machinery, steel arches and props and tools. Sanction has been given to Firth-Vickers Stainless Steel Company, Limited, for carrying out extensions of their capacity for rolling stainless-steel sheets and strip. The estimated cost of the extensions is 1,000,000*l.* It is expected that the present outputs will be doubled when the scheme is completed in the course of two to three years. The main units of the hot-rolling equipment have been ordered from Davy and United Engineering, Limited, Sheffield.

South-Yorkshire Coal Trade.—Unofficial strikes have retarded the production of coal and added to the difficulty of building up reserve stocks at works and house-coal depots. Holidays at some pits have accentuated the shortage of coal. Some small improvement of reserves at gasworks and electric power stations has been made. More coking coal is required to meet the demand for supplies for current use and for stocking. All coke production is reserved for the home market.

RETURN TO SERVICE OF M.S. "DURBAN CASTLE."—The Union-Castle liner, Durban Castle, which saw considerable service during the war in trooping and on invasion operations in the Mediterranean, has been reconditioned by her builders, Messrs. Harland and Wolff, Limited, Belfast, and will sail from Southampton on July 17, on the mail service to South Africa. She has accommodation for 540 first and tourist-class passengers. As a troopship, the Durban Castle made voyages to India, Canada, South Africa and Australia, and later, in the capacity of a Landing Ship, Infantry, was detailed as headquarters ship in the invasion of North Africa, and also took part in the operations on Sicily and the south of France. During her war service, the vessel carried 168,200 passengers and travelled 459,855 miles.

NEW MAGNETIC MATERIAL FOR SMALL MAGNETS.—The Plessy Company, Limited, Ilford, Essex, have recently introduced a powder which, it is claimed, enables expensive machining operations to be eliminated or reduced in the manufacture of small permanent magnets for radio and other electrical equipment. This powder consists of a mixture of iron and cobalt oxides with a small quantity of plastic binders, and it can be rapidly moulded into any desired shape. The density of the material, which is known as Caslox, is 3·2 gm. per cubic centimetre, and its specific resistance is $0{\cdot}5 \times 10^{6}$ ohms per centimetre cube. Its coercive force is high, so that it is little affected by disturbing magnetic fields. We understand that the moulded Caslox is reasonably stable at temperatures up to 70 deg. and is unaffected by humidity and atmospheric impurities. Tests have shown that it has a long shelf life.

THE DEVELOPMENT OF ALL-WING AIRCRAFT

(*For Description see Page 45.*)

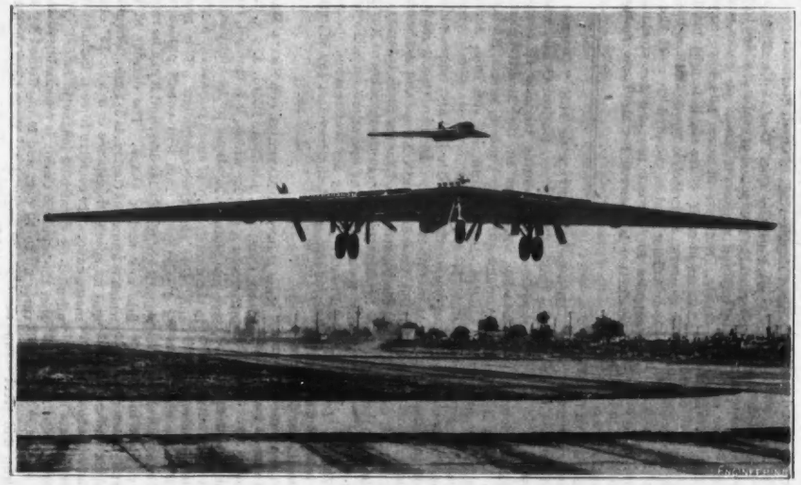


FIG. 1. NORTHROP FLYING BOMB AND XB-35 BOMBER SHOWN TO SAME SCALE.

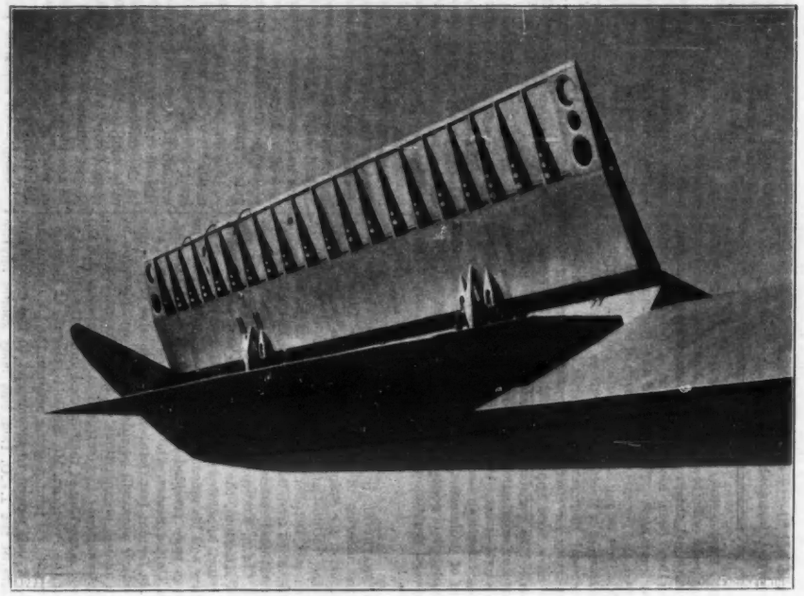


FIG. 2 WING-TIP CONTROLS ON XB-35 HEAVY BOMBER.

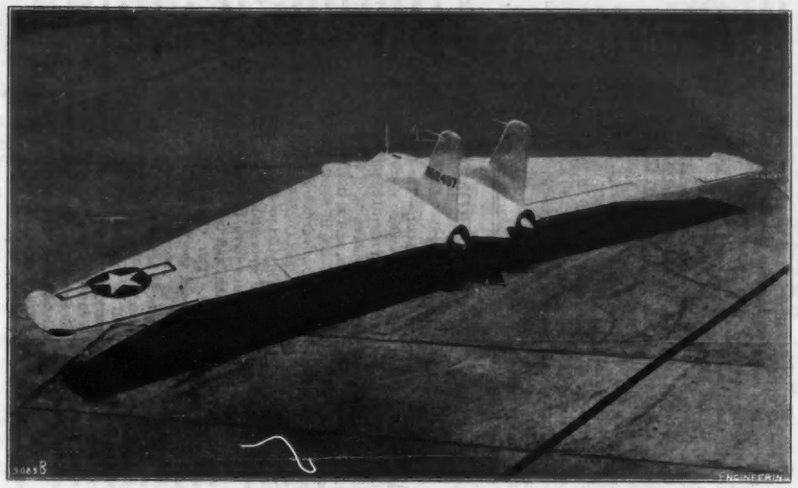


FIG. 3. NORTHROP XP-79B TURBO-JET AEROPLANE.

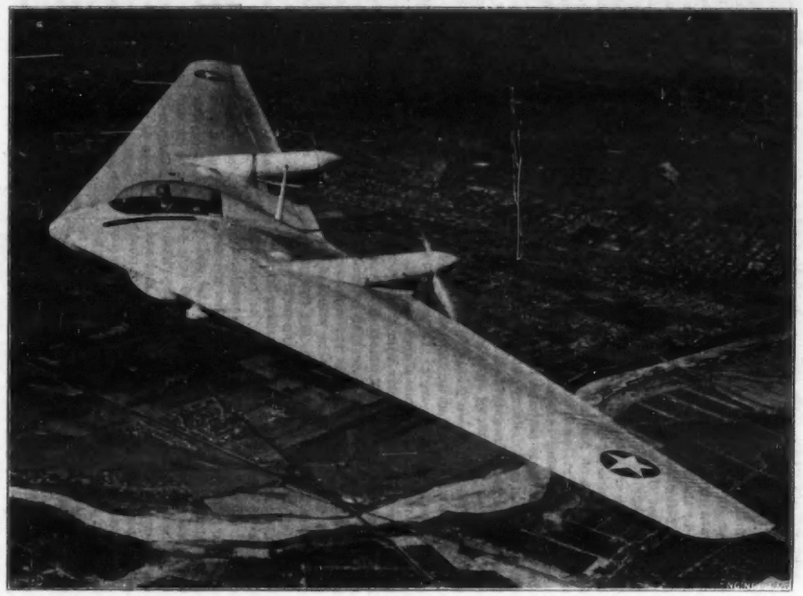


FIG. 4. FLYING MODEL OF NORTHROP XB-35 HEAVY BOMBER.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, JULY 11, 1947.

VOL. 164. No. 4250.

SHIPPING LOSSES IN THE SECOND WORLD WAR.

ON August 1, 1919, the House of Commons ordered a return to be made of the losses of British merchant vessels during the 1914-18 war, and another of the losses sustained by the Royal Navy, both returns to show how and where the vessels were lost. They were "Ordered, by the House of Commons, to be printed" on August 19, 1919—slightly more than nine months after the armistice. Within the past week, the corresponding returns for the second world war have been placed on sale by H.M. Stationery Office—more than two years after the end of the war in Europe, and at an aggregate retail price of 8*s.* 6*d.* as against 1*s.* 10*d.* in 1919. There are slight differences in arrangement between the two sets of information, and the 1947 return for merchant ships does not give the numbers of lives lost in the individual ships, which the 1919 return did give; but, broadly speaking, the returns are comparable, and very interesting the comparison must be to all who have followed the fortunes and misfortunes of British shipping during the two wars and in the difficult years between them.

It is convenient to summarise the warship losses* before those of merchant ships, as it was the earlier of the two returns to be released. It contains a list of the losses of warships and auxiliary vessels, arranged according to the year and the type of ship; a summary of the losses, by year and class; an analysis of the causes of loss, by classes; a summary of losses, by year and cause; and a classified nominal list of losses. The foregoing constitute Part I of the return; in Part II, forming part of the same publication, appear the figures relating to landing ships, landing craft, and barges, arranged in a list, according to year and class, and a summary of losses. There is also a comprehensive nominal index. The returns do not include ships of the Dominion and Royal Indian navies, or small vessels of 10 tons or less, but they do include requisitioned vessels, which are indicated as such in the main lists.

The first British warship lost was sunk as the result of an accident—the submarine H.M.S. Oxley, off Norway on September 10, 1939; and the last, down to September 2, 1945, which is the end of the period covered, appears to have been motor torpedo-boat No. 261, stated to have been "sunk at Alexandria" on August 26, 1945, the cause of the sinking not being given. Between those two events, the Royal Navy suffered the loss of 1,503 vessels, including three battleships (Royal Oak, Barham and Prince of Wales), two battle cruisers (Hood and Repulse), five aircraft carriers (Courageous, Glorious, Ark Royal, Hermes and Eagle), three auxiliary aircraft carriers, 23 cruisers, 139 destroyers, 76 submarines, 15 armed merchant cruisers, 11 sloops, ten frigates, 28 corvettes, 115 motor torpedo-boats, and 28 motor gunboats. It is not possible to quote an overall figure for the tonnage, as part is displacement and part is measurement.

Some of the above classes of warships had no exact counterparts in the 1914-18 war, but for the main categories the corresponding figures can be quoted and are of some interest. In the 4¼ years of the previous war, the Navy lost 254 warships and 815 auxiliary vessels, a total of 1,069; and the warship total included 13 battleships, three battle cruisers, 25 cruisers, 64 destroyers and 11 torpedo boats, three flotilla leaders, three aircraft carriers, 18 sloops and 54 submarines. It would be reasonably accurate to class together the destroyers, torpedo boats and flotilla leaders, making a total of 78 in this category, compared with the 139 lost between 1939 and 1945; but in no case can the comparison of the two wars be pushed very far—there is a great difference, for instance, between the type and average size of the battleships in the respective cases, and some of the 1939-45 destroyers were more formidable craft than many of the 1914-18 cruisers. The closest comparison, class for class, is probably in that of submarines, where the rate of loss is almost identical in the two wars—roughly, one a month. That the rate was not much higher in 1939-45 is rather remarkable, considering how serious a menace aircraft became to the submarine, especially in the comparatively shallow waters where much of the British submarine navigation was done.

The expenditure of landing craft was wholesale, as was to be expected—20 landing ships and 1,308 craft and barges; and their variety is hardly less impressive. Only five types of landing ship figure in the return, but there are 42 distinct classes of landing craft and landing barges. The heaviest casualties, naturally, were among the assault craft, of which 360 were lost, the next heaviest being the Landing Craft Personnel (Large), 160; Landing Craft Mechanised (Mark I), 141, and (Mark III), 133. A considerable number were lost by stress of weather, and some others, of the smaller types, sank with the ships which were carrying them as cargo. Of the warship losses, of course, not all were due to enemy action; of the total of 1,503, 545 were attributed to "other causes." The analysis is as follows. Losses due to enemy action were: by mines, 281; aircraft, 271; submarines, 172; surface craft, 109; by ramming, 5; by shore batteries, 4; and "cause unknown," 116. Losses by other causes than enemy action were: wrecked, 114; vessels used as blockships, 89; collision, 85; accident, 38; fire, 37; sunk by British forces, 28; unknown causes, 154. The worst year, in point of numbers lost, was 1942, when the total reached 359, including two aircraft carriers, eight cruisers, 46 destroyers and 18 submarines. Of the losses of which no details are given, perhaps the most curious are the five ammunition hulks which disappeared ("cause and place unknown") between September 14 and 29, 1939. They were all vessels of some size—1,700 to 2,000 tons register—and, presumably, former merchant ships, judging by their names. The strange feature is that they are the only ammunition hulks in the entire list and that all were lost within a fortnight, four of them in two days.

At the outset of the war, it was freely predicted that the losses of merchant tonnage would be on a scale more severe than in the previous war, because

* *Ships of the Royal Navy: Statement of Losses During the Second World War.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* 6*d.* net.]

of the great increase in average size, and the reduced number, of cargo vessels under the British flag in 1939 compared with a quarter of a century earlier. This prediction was fulfilled, so far as can be judged from general indications; though a direct comparison of the corresponding British official figures is impracticable because the return for 1914-18 summarises losses of British ships only, totalling 7,759,090 gross tons of merchant ships plus 71,765 tons of fishing vessels, and the 1939-45 return includes, in the one table, British, Allied and neutral merchant and fishing vessels, the grand total being 21,194,000 gross tons. Undoubtedly, however, the position would have become much more serious if, in the second world war, the convoy system had not been introduced from the beginning of hostilities, and if the protection of ships by aircraft had been less speedily developed.

Particulars of the losses of mercantile tonnage are contained, as stated above, in a separate publication,* from which it appears that the number of British merchant ships (other than fishing craft) lost by enemy action in the six years from September 3, 1939, to September 2, 1945, was 2,426, of an aggregate gross tonnage of 11,331,933. The 7,759,090 gross tons quoted above for 1914-18 represented 2,479 ships, so that the 1939-45 figures bear out the prediction of the effect of building larger ships, though it is interesting to note that the enemy required almost 50 per cent. more time to sink practically an identical number of vessels. The totals emphasise once again the vital necessity to Britain of an adequate mercantile marine and a vigorous shipbuilding industry, and even more do they underline the immense debt that the Allies owe to the shipbuilders of the United States, without whose extraordinary efforts the maintenance of seaborne supplies and a successful outcome of the war would have been impossible.

Of the 2,476 ships that were lost, 1,332, totalling just under 7,600,000 gross tons, were sunk by enemy submarines, 296 by mines, 209 by surface craft, 383 by aircraft, and 206 from other causes, details of which were unknown in many cases. The first vessel to be sunk, as will be well remembered, was the liner Athenia, torpedoed by a German submarine on the first day of the war. The last, also torpedoed by a submarine, was the steamer Avondale Park, sunk off May Island, in the Firth of Forth, on May 7, 1945. The losses, year by year, were, in 1939, 96 ships of 419,015 tons; in 1940, 548 ships, totalling 2,435,667 tons; in 1941—the worst year in point of numbers—717 ships, of 2,824,056 tons; in 1942, when most tonnage was sunk, 646 ships, of 3,459,923 tons. Thereafter, the Allied counter-measures became increasingly effective. In 1943, the total of ships lost was reduced to 273, of 1,514,221 tons; in 1944, 103 ships, of 489,040 tons were lost; and in 1945, 43, of 190,011 tons. The losses of fishing vessels were 136 craft, of 24,525 tons, 55 of them sunk in 1941.

An analysis by the Admiralty of the mercantile losses in 1939-45, compared with those of 1914-18, though issued in connection with the publication of the official return, differs from it in certain of the figures, apparently by reason of a different overall period being taken and, possibly, because some of the ships included, though merchant ships in type, were in the service of the Navy and other forces when they were destroyed. The statement is of particular interest, however, as showing the rates of loss attributable to submarines only, and the beneficial effect of the convoy system. It shows that, in 51 months of the 1914-18 war, enemy submarines sank 4,837 Allied merchant ships, an average of about 95 a month, and that the average gross tonnage of the vessels lost was 2,300. In the 1939-45 war, over a period of 68 months, the sinkings by submarine totalled 2,775, or about 41 a month, of an average tonnage of 5,250 gross. The efficacy of the anti-submarine measures in the second world war is strikingly demonstrated by the fact that, whereas approximately 178 enemy submarines were destroyed in the 1914-18 struggle, the attempt to strangle the Allied seaborne traffic in 1939-45 cost the enemy 996 submarines.

* *British Merchant Vessels Lost or Damaged by Enemy Action During Second World War.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 5*s.* net.]

THE TEACHING OF STATISTICS.

IN his presidential address to the Mathematical and Physical Sciences Section of the British Association, in 1938, Sir Charles Darwin expressed the hope "that generations will grow up which have a facility that few of us at present possess in thinking about the world in the way which the quantum theory has shown to be the true one. The inaccuracies and uncertainties of the world will be recognised as one of its essential features." Classical physics was conceived in terms of exact laws and unique quantities determined with perfect precision; modern physics has to deal with aggregates, statistical laws and quantities subject to errors and variations which occur with various probabilities. As a very simple instance, it is never possible to say that a certain object is exactly one inch long, but if it is one of many similar objects, statistical investigation will establish the probability that it will not differ from one inch by more than a specified amount. At one time, statistics was, and in many dictionaries still is, defined as the science which deals with the collection and classification of facts relating to the domestic economy, health, weather and other aspects of a community; its meaning has now been extended to cover the collection, examination and arrangement of data relating to natural phenomena.

The most striking case of the application of statistical methods in the engineering field is furnished by the system of quality control which has been applied in practice on a considerable scale. The common method in industry is to employ "go" and "not go" gauges in checking the dimensions of finished, or partly-finished, parts and to impose upper and lower limits for such properties as mechanical strength or electrical resistance. It has been found, however, that the effective use of data obtained during manufacture substantially reduces the need for checking for conformity to specification. The importance of statistical methods in the social sciences is now fairly generally recognised, but they are equally of importance in biology and medicine. Most quantitative biological laws are statistical, in that they apply to groups rather than to individuals, and a knowledge of statistical procedure is of great value in planning experiments and interpreting results.

Although most trained engineers will be able to employ quality-control methods, a very large number will have but little knowledge of their scientific basis. Sir Frank Gill, at a joint meeting of the three major engineering institutions, held on April 15, 1942, suggested that this state of affairs need be no handicap to the utilisation of quality control. "Factory engineers should at once begin to study the rules for the application of quality control and not by studying the statistical foundation. They should accept this foundation as already established and proceed with practical study." This is sound advice, but does not alter the fact that the most effective use of any procedure is not likely to be made by those having no proper grasp of its fundamental basis. An illustration is furnished in a recent publication of the Royal Statistical Society in which it is stated that "experimentalists, trained only in the 'classical' methods of the exact sciences . . . sometimes when they have turned to statistical methods for aid, have done so without adequate study and with a *naïveté* that has rendered their work ineffective."

Advanced statistics is a specialised branch of mathematics and most scientific workers have not the time, even if they have the inclination, to make it the subject of extensive study. The simpler procedures of the matter are understood by many engineers; they are familiar with the construction of frequency diagrams, or probability curves, but few would be capable of applying regression analysis, by which it is possible to isolate the effect of each independent variable in a system on the dependent variable. Most of them are not required to do so, but they are likely to be able to utilise the results of statistical analysis more intelligently, and to know when it may be usefully employed, if they have a broader knowledge of the fundamentals of the matter than is now common. The purpose of the publication* of the Royal Statistical Society, referred to above, is to urge that statistics should be taught as a specific subject in universities, university colleges and technical colleges of university rank.

In the main, the proposals are not concerned with the training of statisticians *per se*, but with the need for creating a more widespread knowledge of the statistical approach to problems in a very wide field of activity. It is recognised that there is an unfulfilled demand for fully-trained statisticians and is stated that "in a number of cases in the Government service, in the universities and in industry, it has been found impossible to fill . . . posts with persons having the qualifications desired." The proposals for the institution of statistical courses in universities generally, if implemented, would probably do something towards increasing the supply of professional statisticians, as a greatly extended range of students would be brought in touch with the subject and a proportion would be likely to be attracted towards a statistical career. At present, the University of London is alone in offering a bachelor's degree in statistics, but even in it there is no uniformity of practice in the different colleges.

For the purpose of providing a background knowledge of statistical methods and a wider appreciation of the possibilities of application of the subject, it is proposed that elementary courses in statistics should be instituted in all universities. These would familiarise students with statistical ideas and the most commonly used elementary methods. It is suggested that these courses need not be long and that ten lectures would probably suffice. No special mathematical ability would be necessary in the students and stress would be laid on the practical use of statistical methods. It is added that students who come to a university to take a special course in preparation for work in the public services are frequently found to have had a quite inadequate training in elementary mathematics and arithmetic. It is not likely that this remark can be extended to cover the average engineering or physics student, but the elementary courses would be of value in giving an insight into method and procedure.

This elementary instruction should be followed by courses which are described as "ancillary." Their purpose would be to enable students properly to utilise statistical methods in the problems of their particular science. This would involve separate courses for different sciences, as the practical examples of the application of statistics which would be studied, clearly could not be the same for, say, engineering and biological students. It is not suggested, however, that all engineering students would find it necessary to attend such an ancillary course, although it is considered to be essential for those concerned with the social and biological sciences. The elementary instruction would probably suffice for most engineering students.

The science of statistics provides valuable methods for dealing with many of the problems of practice, but it cannot be utilised most effectively without a good knowledge of the field of application. With the elementary instruction suggested for all science students, the professional worker in any scientific field would be able to utilise its methods for everyday purposes and when the complexity of a problem required that he should consult a professional statistician, his knowledge of the fundamentals of the subject would enable him to postulate his requirements in exact terms and to examine critically the results of the statistician's work. It is clearly necessary for any professional statistician to learn enough of any field of application to appreciate the relation of his work to the practical problems of the subject with which it is concerned. He cannot, however, be both a statistician and a specialist in a range of different sciences; for his work to be effective he must act in co-operation with a scientist trained in the particular subject concerned. The essential text of the Royal Statistical Society's report is that co-operation can only be most fruitful when the scientist trained in the particular subject also has an adequate background knowledge of statistical methods.

* *The Teaching of Statistics in Universities and University Colleges.* The Royal Statistical Society, 4, Portugal-street, London, W.C.2. [Price 6*d.*]

NOTES.

THE INSTITUTION OF CIVIL ENGINEERS.

THE first post-war summer meeting of the Institution of Civil Engineers was held on the North-East Coast on July 3 and 4, with headquarters at Newcastle-on-Tyne. The members met informally on the evening of Wednesday, July 2, at the Royal Station Hotel, but the official proceedings opened on the following morning, when the Institution was welcomed by the Lord Mayor (Alderman James Pearson) and Lord Eustace Percy, Rector of King's College, University of Durham. A technical session followed, in the physics lecture room of King's College, when two papers were presented and discussed; these were on "The History and Development of the Tyne," by Mr. R. F. Hindmarsh, T.D., M.I.C.E., and "The Engineer's Place in the Community," by Mr. A. Floyd, C.B.E., M.I.C.E. The afternoon was devoted to a launch trip down the Tyne from Newcastle to North Shields, and visits to the Walker Naval Yard of Messrs. Vickers-Armstrongs Limited, the Heaton works of Messrs. C. A. Parsons and Company, Limited, and the Dunston power station of the North Eastern Electric Supply Company. In the evening, a dinner was held in the Royal Station Hotel, the members and guests being received by the President (Sir William Halcrow), and the chairman of the Newcastle and District Association of the Institution, Mr. Percy Parr (City Engineer of Newcastle), who was accompanied by Mrs. Parr. The second day of the meeting, July 4, was spent in whole-day visits to works and other places of interest, including the Roman camp at Housesteads and the Roman bridge at Chollerford, under the guidance of Dr. I. A. Richmond; the port of Sunderland, where the party was welcomed by members of the Town Council and of the River Wear Commission, and subsequently taken to the new power station of the Sunderland Corporation, and to the Pyrex glass works; and the Billingham works of Imperial Chemical Industries, Limited. The meeting concluded with a civic reception by the Lord Mayor and the City Corporation of Newcastle.

BRITISH NON-FERROUS METALS FEDERATION.

The second annual general meeting of the British Non-Ferrous Metals Federation was held in Birmingham on Thursday, July 3, under the chairmanship of the President, Mr. Horace W. Clarke. At the morning session of the meeting, the following officers were elected for the year 1947-48: as President and chairman of the executive committee, Mr. Horace W. Clarke; as vice-presidents, Mr. W. H. Henman, Mr. H. E. Jackson, and Mr. W. J. Terry; as treasurer, Mr. R. Lloyd Gibbins; and as auditors, Messrs. Peat, Marwick, Mitchell and Company. The offices of the Federation are at 132, Hagley-road, Birmingham, 16. In the afternoon, the annual meeting of federated firms was held, and, at this, the President submitted a report on the work of the Federation for the year 1946-47. Mr. Clarke stated that the manufacture of non-ferrous metals continued to be, to some extent, a partnership between H.M. Government, who were the only purchasers and suppliers of raw material to the industry, and the industry itself. The first duty of an organisation such as the Federation was to represent the industry, in its relations with the Government, in accordance with the best interests of all parties concerned. The correct attitude to adopt was one of helpful co-operation and a readiness to understand the complicated economic problems of modern government, tempered by a reasonable firmness on all important issues where the vital interests of the industry were involved. Among other matters, it had been agreed with the Ministry of Supply that the Federation should act as a channel of communication on all questions of manufacturing priorities and that they would endeavour, through the co-operation of federated firms and members of the industry's export group, to meet the requirements of Government departments or other users whose claim to priority was sponsored by the Ministry. This scheme had worked with very considerable success from the outset. The statistics department of the Federation had continued their valuable work and had grown in importance. The Federation had also been active in the international field. A committee, upon which several countries were represented, had been established for the mutual discussion of common problems of post-war reconstruction and it was felt that this work was of considerable importance.

ELECTRICITY SUPPLY IN NORTH SCOTLAND.

On Friday, June 13, the North of Scotland Hydro-Electric Board published details of the Storr Lochs constructional scheme in the island of Skye. This scheme, which is the first to be developed in the Western Isles, will have an initial output of 1,750,000 kWh and an ultimate output of 5,500,000 kWh per annum. The site of the project is in a valley south of the precipice of Storr between Portree and Staffin. Here a gravity dam, 170 ft. long and 36 ft. high, will be erected, which will raise the level of Loch Leathan almost to that of Loch Fada; and thus provide a storage reservoir of some 87,000,000 cub. ft. This reservoir will be supplied from a catchment area in which the average annual rainfall is about 59 in. To begin with, a pipeline 2,800 ft. long will carry the water from the loch to a generating station near the mouth of the Bearreraig River. Subsequently a second pipe line will be constructed. Initially, the station will contain one 800-kW set, which will operate at a gross head of 440 ft. The ultimate capacity, however, will be 2,400 kW. Electricity from this station will be distributed in accordance with the Board's scheme for Skye. This will involve the erection of 178 miles of high-tension and 151 miles of low-tension lines, and will make electricity available to over 70 per cent. of the population of this island, which covers 647 sq. miles. Schemes for the distribution of electricity in the Ullapool district of Ross-shire and the Islands of Lewis, Islay and Shetland were announced on Monday, June 30. In Lewis, the Eye Peninsula and North Tolsta will be dealt with first, though the scheme will eventually cover the whole island. In Shetland, the first step will be to extend the Board's distribution line from Lerwick to Scalloway. In Islay and at Ullapool supplies will be given from Diesel generating plant.

THE ASSOCIATION OF CONSULTING ENGINEERS.

The recently issued annual report of the Association of Consulting Engineers for the twelve months ended April 30, 1947, shows that the membership had reached 228 at that date—the highest in the 34 years of the Association's history. The chairman during the year under review was Mr. G. Howard Humphreys, M.A., M.I.C.E. (who has now been succeeded by Dr. J. F. Crowley) with Mr. J. R. Beard as deputy chairman. During the year, special committees were closely concerned with the preparation of a new form of "General Conditions of Contract and Forms of Tender," now issued jointly by the Institution of Civil Engineers and the Federation of Civil Engineering Contractors; and with model agreements and professional rules, which are still under consideration with the various Ministries. The Association also maintained contact with the British Standards Institution, the National Register of Electrical Installation Contractors, and other bodies directly concerned with professional matters. In the course of the year, the chairman made 86 nominations in cases where the advice of the Association was sought regarding the appointment of consulting engineers, the applications coming from a number of Government departments, as well as from local authorities and commercial firms.

SOUTH WALES LABORATORY FOR THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION.

While London is the natural administrative centre for activities that are organised on a nation-wide basis—despite the tendency of certain Government departments towards decentralisation in this respect—it is equally natural that industrial research should be centred in the areas whence the problems arise and where the results of the studies are to be applied. It is appropriate, therefore, that the British Iron and Steel Research Association should select South Wales as a site for one of their series of laboratories, concerned more especially with work on metal surfaces and with coatings on steel. The South Wales Siemens Steel Association and the Welsh Sheet and Plate Manufacturers' Associations have had research committees at work in Swansea University College since 1932, and arrangements were made rather more than a year ago for the British Iron and Steel Research Association to take over the functions of these committees, which are now to be continued and expanded in a new establishment at Sketty Hall, situated on the outskirts of Swansea and within convenient reach of the University College. The opening ceremony took place on Thursday, July 3, when Mr. G. H. Latham, President of the British Iron and Steel Research Association, received from the Mayor of Swansea (Alderman Harry Davies) a gold key with which he admitted the representatives and guests of the Association, the University College and the Corporation of Swansea, from whom the building is being leased. The organisation of the laboratory is in the hands of the Coatings Committee of the Mechanical Working Division of the Association, though work for other divisions will be carried on there as needs and opportunity arise, and the equipment has been installed under the direction of Mr. D. Luther Phillips, M.Sc., who will be in sole charge of the researches, as he was formerly of the work of the earlier associations, under Principal C. A. Edwards, at the University College. The scope of the research to be undertaken at Sketty Hall is indicated by the terms of reference of the Coatings Committee, namely, "To consider and investigate all matters concerning metallic and other inorganic coatings on steel and all processes for surface preparation associated therewith"; and those of the South Wales Steel Sub-Committee, whose concern it is "To discuss and investigate the manufacture of steel for flat steel products."

CERTIFICATION OF ELECTRICITY METERS.

It was laid down in Section 3 of the Electricity Supply (Meters) Act, 1936, that all uncertified meters installed before July 1, 1938, were to be replaced within ten years from that date. In February, 1946, this period was extended until June 30, 1950, by an Order in Council, but at the same time undertakings were advised of the steps they should take in anticipation of the resumption of compulsory certification. It was pointed out by the Electricity Commissioners at the same time, that uncertified meters installed since August 1, 1943, when the requirements regarding compulsory certification were suspended by a Defence Regulation, would have to be replaced before that regulation was revoked. We understand that the stage has now been reached when this revocation can take place; and that steps are being taken so that the repeal will become effective as from October 1, 1947. Electricity undertakings are, therefore, reminded that after the date of revocation it will be obligatory for all meters installed, other than by special agreement, to be certified; and that ordinary consumers will have a right to require a certified meter. Undertakings who have not yet replaced uncertified meters installed since August 1, 1943, or who are not yet in a position to recommence certification, should take the necessary steps forthwith; and should consult the Meter Examiners in regard to any difficulties. When normal certification is resumed, it is anticipated that the Meter Examiners will deal with all certification requirements during their periodical visits to undertakings. The Commissioners, however, will be prepared to continue postal certification for the time being, in cases of exceptional urgency. Certification of meters at the manufacturers' own testing stations will also be permitted temporarily. The normal testing of apparatus and the approved methods of testing meters will also be resumed, the relaxations in this respect which have been permitted since July, 1940, being withdrawn, with certain exceptions.

INTERNATIONAL CONGRESS FOR ENGINEERING EDUCATION, DARMSTADT.—An International Congress dealing with problems of technical education is being organised by the Technische Hochschule, Darmstadt, and will be held from July 31 until August 9. We understand that scientists and engineers from a number of countries are to present papers. Further particulars may be obtained from the Technische Hochschule, Darmstadt, Kongressleitung 16, Darmstadt, U.S.-Zone, Germany.

LETTERS TO THE EDITOR.

JORDAN VALLEY IRRIGATION IN TRANSJORDAN.

TO THE EDITOR OF ENGINEERING.

SIR,—On page 241 of your 162nd volume (1946) there appeared an article by Mr. M. G. Ionides, under the above title, on the utilisation of the water resources of Transjordan and Palestine; a subject on which he had previously delivered a lecture to the Royal Central Asian Society, printed in their *Journal* of October, 1946. I should like to submit the following observations on the views expressed by Mr. Ionides.

He is correct in stating that, where the reserve of land exceeds that of water, the agricultural lot viable of an agricultural earner and his family may be defined by a certain unit of water rather than by a unit of land. We accept the assumption that 100 dunams of cultivable land, receiving an average rainfall of, say, 500 mm. a year, can serve as such a unit for a family of five which subsists on agriculture maintained by dry farming. However, to take the country's total rainfall and divide it by the average precipitation of 50,000 cub. m., falling on such a unit, in order to establish the total number of available units and thereby the size of the agricultural population, is a method of calculation justifiable only under conditions that do not provide for any development scheme; the agricultural population could be nearly doubled by the inauguration of special projects aiming at the exploitation of the total utilisable run-off water. This statement is based on the following considerations.

Fairly thorough investigations have led to the conclusion that the total utilisable run-off (including the Jordan River and half of the Yarmuq River) constitutes about a third of the total rainfall, say, 2·8 billion cub. m. Average water requirements in irrigated farming are estimated at roughly 700 cub. m. per dunam for a lot viable of 25 dunams, which works out at approximately 17,500 cub. m. per unit per annum. This is just about a third of the 50,000 cub. m. assumed to be required for extensive agriculture. If the total utilisable run-off of 2·8 billion cub. m. is divided by 17,500, an additional 160,000 agricultural units of irrigated land are obtained. Even if we bear in mind that a maximum of 500 million cub. m. would go towards other than agricultural purposes (industry, drinking water and inevitable losses), there still remain 130,000 additional units in irrigated farming.

It should be noted that the above calculation is based on an average water requirement of 700 cub. m. per irrigated dunam, additional to the direct rainfall, a figure which has been established by the Agricultural Experimental Station of Rehobot as a result of many years' study of the country's agriculture. On this point, moreover, there is no disagreement between Jewish experts and those of the Government of Palestine. The figure is, of course, considerably lower than Mr. Ionides's figure of 1,690 cub. m. per dunam, which is based on conditions in the Lower Jordan Valley, where the water duty is the highest in the country.

Mr. Ionides is of opinion that, in olden times, a more bountiful rainfall was responsible for more prosperous agriculture. This view is not shared by meteorologists or archæologists, who refute the contention that the decay of Palestine's agriculture is connected in any way with basic changes in the country's climate. He is probably correct in his statement that, in historical times, the city population was maintained by non-agricultural pursuits. The view at present prevailing among economists in Palestine is that to-day, no less than then, the livelihood of the town population must be based mainly on urban callings. It is clearly realised that a well-established urban population is a prerequisite for the development of local agriculture and that the agricultural population should never be more than a certain percentage of the total population. This percentage is at present put by economists at no higher a figure than 15. This entirely accords with Mr. Ionides's statement in ENGINEERING: "It is wrong to say that, if Palestine and Transjordan were well cultivated, they would be rich. The truth is the opposite; if they were rich, they would be well cultivated." In a way, Jewish immigration into Palestine has acted in accordance with his formula; the immense influx of capital into the country has led to a marked rise in the standard of agricultural cultivation.

As regards water resources in Palestine, a few points are worth stressing. In his lecture to the Royal Central Asian Society, Mr. Ionides stated that, "unless the water is flowing into the underground reservoir from which the well draws, the level of the water will drop and the reservoir will be drained. That is what is happening now in the coastal plain. The water is being taken out in greater quantities than it is being put in." This statement is far from being correct, and seems to overlook an elementary principle of hydrology. The underground water table, during many thousands of years, had adopted a slope towards the sea which was sufficient to maintain a general equilibrium between the infiltrating rainwaters and the outdraining underground water. As water is now pumped out of the underground reservoir, the total quantity of water which must drain to the sea each year is proportionately reduced, and the slope of the water table towards the sea is reduced accordingly, until a new equilibrium is set up in each district. The reduced slope towards the sea naturally involves a drop in the water table, which is greater the farther one goes from the sea; but such a drop does not indicate that water is being taken out in greater quantities than it is being put in. It is merely an indication of reduced drainage towards the sea and water going to waste. Observations and calculations have shown that very ample reserves of underground water can still be withdrawn without exceeding the annual input; in fact, the official opinion of the Palestine Government experts is that water supply from wells can be increased to three times its present figure, whereas the investigations of the Water Research Bureau (W.R.B.) of the Jewish National Institutions have led them to the conclusion that this figure is an under-estimate, and that the present consumption of underground water is no more than one-fifth of what may safely be withdrawn.

If we accept Mr. Ionides's figures of 10 per cent. for surface run-off and of 7,500,000,000 cub. m.* per annum for total rainfall, we have a surface run-off of 750,000,000 cub. m. per annum, which is by no means negligible as compared with the total of 2,800,000,000 cub. m. per annum given above. Even if less than the whole of this surface run-off can be utilised, it still represents an appreciable potential source of additional water for irrigation.

Mr. Ionides argues that the utilisation of the Jordan River is entirely dependent upon agreements with the Governments of Syria and the Lebanon, since this water comes from an area outside Palestine. Two of the Jordan's main tributaries, namely, the Banyas and the Hasbani, indeed rise in Syrian and Lebanese territory, respectively. Under the Bon Voisinage Agreement, concluded after World War I, there was to be a final delineation of Palestine's northern frontier, after consultation with water experts, so as to assure the proper utilisation of the waters of these tributaries for Palestine. This, however, was never done. Possibilities of additional utilisation of the waters of the Banyas and Hasbani within Syria or the Lebanon are extremely limited owing to the nature of the terrain there, and, in the case of the Hasbani, also by reason of its very low dry-weather flow.

Calculations have been made by the W.R.B. to ascertain the extent to which the waters of the Jordan tributaries can be made available for irrigation if the necessary headworks had to be erected within the boundaries of Palestine. These calculations have shown that the amount of water utilisable at the level of the Leidani springs represents roughly 85 per cent. of the total flow of the three main tributaries of the Jordan River, the remainder also being utilisable, but downstream, at a lower level. As regards the waters of the Litani, the position is even simpler. The greater part of the water of this river cannot physically be utilised by the Lebanon, because no suitable areas are available for irrigation. It is proposed, therefore, that Palestine should procure from the Lebanon this superfluous water, which would otherwise run unused to the sea. Such an arrangement could only be of advantage to both sides.

As to Mr. Ionides's proposal for irrigation and development in Transjordan by the utilisation of the Jordan and Yarmuq waters: this, too, can serve as a point of co-operation and mutual assistance—this time, between Palestine and Transjordan—and need not represent a point of conflict between the countries concerned. As a matter of fact, the Hays-Savage "Jordan Valley Authority" scheme also included an allocation of water for irrigation in Transjordan. It is somewhat doubtful whether all of the additional quantity of 384 million cub. m. of water per annum, assumed by Mr. Ionides, will actually be required to be withdrawn from the Jordan and Yarmuq rivers for use in Transjordan. Mr. Ionides's studies of the water resources of that country are based on only one year's gaugings, made nine years ago. Since then, some additional insight has been gained into the water conditions of Transjordan and, according to this later information, the resources may be put much higher than Mr. Ionides's estimate of 581 million cub. m. based on his studies of 1937-1938. Hence, it is quite possible that a considerable amount—if, indeed, extra water should be required—can be covered by this additional water, available locally. His maximum programme of development in respect of Transjordan is, therefore, perfectly compatible with the proposals of the American engineers for the Jordan Valley Authority.

On the other hand, Mr. Ionides disregarded a number of points which have been taken into account by the American engineers, and which could be settled to mutual satisfaction between the two countries in question. Suitable storage sites on the Yarmuq River are limited and, as far as is understood, Mr. Ionides proposes the use solely of the dry-weather flow of that river. This he intends to supplement with water from the Sea of Galilee. The storm-water flow of the Yarmuq, which may reach as high a figure as 2,000 cub. m. per second, would thus be entirely wasted. There is no reason why this flow should not be diverted to the Sea of Galilee, as proposed in the Hays-Savage Scheme, and stored there for irrigation in either Palestine or Transjordan as required, at the same time serving to maintain the level of the Sea of Galilee, which would otherwise drop as a result of the withdrawal of water for irrigation. The diversion of so large a quantity of water from the Jordan would lead to a drop in the level of the Dead Sea granted to the Dead Sea concessionaire by the Governments of both Palestine and Transjordan. It is wise to foresee this difficulty, and the American engineers have done so; in their scheme, they propose the introduction of water from the Mediterranean to maintain the level, should this be necessary, and, at the same time, to provide for the generation of cheap electric power.

Mr. Ionides makes a special point of the low cost of the works proposed by him, as compared with those proposed under the Hays-Savage Scheme. The simplicity of his scheme is granted, and is comparable with that of certain sections of the Hays-Savage Scheme; yet the picture he conveyed is not complete. Whereas his estimates are based on pre-war prices, those used in the calculations of the Hays-Savage Scheme have been taken at 20 per cent. above pre-war level. The difference in the cost of the water as between the two schemes is, however, largely illusory. Under the Ionides scheme, areas demanding a very high water duty are to be irrigated, where the quantity of water required for the irrigation of a dunam of land (that is, for the production of a certain quantity of agricultural produce) exceeds by far—in fact, it is almost 2½ times—the quantity normally consumed in Palestine. To render his water price comparable, therefore, it must be increased in the ratio of the water duty between the two areas. If his figure is increased in this proportion, the water price becomes 1¼ mil per cub. m., as against 1·71 mil per cub. m. under the Hays-Savage Scheme which,

* Within the boundaries of Palestine and above Isohyete, of 200 mm.

as stated above, is based on higher unit costs. As a matter of fact, the cost of irrigation water per dunam is probably quite similar under the two schemes.

The irrigation of an additional area of 300,000 dunams in Transjordan, as recommended by Mr. Ionides, would lead to considerable agricultural over-production in that country, compelling it to look for markets abroad. Since irrigation is increased in Syria and the Lebanon as well, the Jewish urban population of Palestine seems to represent the only important market that might come into consideration for Transjordan. Thus, from whatever angle the matter is regarded, it seems clear that co-operation between Palestine, notably Jewish Palestine, and her Arab neighbours can only be of mutual advantage, and it would be well for engineers to promote rather than to hinder it.

Yours truly,
M. SITZ, Assoc. Mem.A.S.C.E.

P.O. Box 283,
Jerusalem.
June 15, 1947.

THE ENGINEERING PROFESSIONS AND THE INSTITUTIONS.

TO THE EDITOR OF ENGINEERING

SIR,—I have read with interest the article by Mr. J. H. W. Turner, on page 447 of your issue of May 30; he brings home points that are seriously engaging the attention of engineers—generally throughout the country. This is made apparent to us by the high measure of recruitment that is taking place as far as the Association of Supervisory Staffs, Executives and Technicians is concerned. Members are enrolling at the rate of a thousand a month, largely for the very reasons outlined by Mr. Turner.

It is true to say that our professional institutions have turned out the finest engineers and technicians in the world. In that respect, they have done a marvellous job; but it is generally accepted to-day that, whatever a man's qualifications and capabilities, he cannot do full justice to his work if his mind is obsessed with the low standard of remuneration which makes life difficult for his family and himself. The engineer, more than anyone else, must be able to apply himself to his job with a completely free mind, and it is for that reason that this Association, after two years of detailed research into the conditions prevailing generally throughout the country, has drawn up a "National Charter" with which it is hoped to remove the difficulties to which Mr. Turner refers. I shall be glad to send particulars to anyone interested. There is a need for adequate remuneration for engineers, but to suggest that they will ever achieve it by individual approach is nonsense.

Yours faithfully,
HARRY G. KNIGHT,
General Secretary,
Association of Supervisory Staffs,
Executives and Technicians.

Premier House,
150, Southampton-row, London, W.C.1.
June 27, 1947.

TO THE EDITOR OF ENGINEERING.

SIR,—In his letter, on page 553 of your issue of June 27, Mr. R. M. L. Elkan referred to the disparity between the theoretical standard of a university degree engineer and one who holds only a pass in a senior institution examination. I can endorse this observation fully. At a recent interview, a chief engineer advised me that, as a young man, I was at a disadvantage because, although I had completed an associate membership examination at the age of 25, I did not possess a Higher National Certificate (or Diploma). In other words, and in plain English, this particular employer saw no value in the A.M.I.Mech.E. examination.

I submit that it would be difficult to think of any profession other than engineering in which so much confusion of thought exists regarding the proper way to establish oneself. May I put forward my own view on professional qualifications? If I were an employer interviewing candidates for a technical appointment, I would select those who had obtained a pass in the membership examination of a leading institution, in preference to a man who had "stopped" at a degree, Higher National Certificate, or Diploma. This would ensure, as far as possible, that I was engaging applicants who were not only efficient slide-rule operators, but who were also well educated and who possessed a command of standard English, both as regards good handwriting and speech free from accent or brogue. In general, such a policy is not followed, because there appears to be lack of confidence in the value of institution examinations for associate membership—such as A.M.I.C.E., A.M.I.Mech.E. and A.M.I.E.E.; I can think of no other reason.

Yours faithfully,
LECTURER IN MECHANICAL ENGINEERING.

London,
July 2, 1947.

THE FIRST 10,000-KW 3,000-R.P.M. TURBO-GENERATOR.

TO THE EDITOR OF ENGINEERING.

SIR,—The correspondence on 3,000-r.p.m. turbo-alternator sets arising from your obituary notice of Mr. A. A. Jude appears to call for a statement of this company's part in the early development of such machines. In your article you stated, with all due caution, that a 10,000-kW 3,000-r.p.m. turbine, designed by Mr. Jude, was, you understood, the first of its type to be built in this country. Mr. R. C. McLeod, in your issue of April 25, 1947, on page 341, pointed out that a description in your issue of December 30, 1921, of a Metropolitan-Vickers 12,500-kW 3,000-r.p.m. set for Lister Driver power station, Liverpool (preceding your description of the 10,000-kW set designed by Mr. Jude and manufactured by Messrs. Belliss and Morcom for West Ham Power Station) might indicate that the Metrovick machine was the earlier. In your issue of May 9, 1947, page 388, Messrs. C. A. Parsons and Company stated their belief that their two 12,500-kW 3,000-r.p.m. sets put into commission by the Mersey Power Company on November 24, 1921, were the first of this capacity and speed.

We would confirm Mr. McLeod's inference that the Metrovick set for Lister Drive power station was, in fact, the first to be put into service. It was ordered on December 5, 1919, and put on load on July 19, 1921. The West Ham set was put on load in October, 1922. Between the date of undertaking the set for Lister Drive and the date of acceptance on load, this Company received orders for nine other sets, including a duplicate for the Lister Drive power station. Altogether, there were in hand in September, 1921, twelve large Metrovick 3,000-r.p.m. sets totalling 144,000 kW. We stated at the time that the Lister Drive machine was the largest in the world to operate at this speed and, so far as we know, the statement has never been questioned. We believe this company also built the first 3,000-kW, 5,000-kW and 10,000-kW 3,000-r.p.m. turbo-generator sets. This lead in high-speed machines was maintained when, in 1926, we built a 3,600-r.p.m. set of 12,500-kW capacity, which we believe also constituted a record.

Yours faithfully,
METROPOLITAN-VICKERS ELECTRICAL COMPANY, LIMITED,
K. G. MAXWELL,
Manager, Publicity Department.

Manchester, 17.
June 26, 1947.

INCREASED EFFICIENCY OF HIGH-TENSION FLUORESCENT TUBES.—The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, announce that, as the result of the use of new fluorescent powders, it has been possible to increase the efficiencies of their 4-ft. and 5-ft. Osram high-tension fluorescent tubes. The initial efficiency (after 100 hours) of the daylight, intermediate and warm-white colours has been raised from 31 lumens to 40 lumens per watt, and the final efficiency from 22 lumens to 26 lumens per watt, the average efficiency throughout life being increased from 24 lumens to 31 lumens per watt. In addition, the average life has been increased by nearly 70 per cent.

THE ROYAL AGRICULTURAL SHOW AT LINCOLN.

THE Royal Agricultural Society's annual show, which was held at Lincoln during the period July 1 to July 4, was of particular interest in that it was the first show to be held since 1939. As a consequence, the exhibits in the implement section gave a good indication of the developments that have taken place during the last eight years. That there have been such developments was emphasised by the fact that nearly 70 new implements were on show and these ranged from self-propelled combine harvesters to a one horse-power tractor. As its motto, "Practice with science" suggests, the Society has always encouraged the use of machinery on the land and by its system of implement trials, and the award of silver medals for new implements and machines, has provided the farmer with a safe guide to the practical advantages to be gained and, at the same time, has encouraged the implement manufacturers.

It is hardly necessary to emphasise the importance of the agricultural industry to this country to-day. The disappearance of our overseas investments and the shortage of dollars makes it imperative that the productivity of the land should be increased. According to the White Paper drawn up during the war and published in March, 1947, on "Agriculture and the Saving of Foreign Exchange," the output of British agriculture could be raised by some 130,000,000*l.* a year, and the paper went on to point out that if such an increase does not take place, our imports of food will have to be increased substantially. Unfortunately, there is a steady drift of man-power away from the land and the farmer is finding it difficult to keep up his present production, quite apart from raising it, and it is obvious that farming will have to be mechanised well beyond the stage reached at present. Mechanisation by itself, however, will not prove sufficient, and the adoption of scientific methods of farming is of equal importance. Mention has been made already of the Society's activities as regards mechanisation, but it is perhaps, not so widely known that it is equally active in the matter of scientific farming. Not all scientific discoveries carry the promise of the laboratory to the fields and the Society is engaged continually on long-term experiments and full-scale field tests, the results of which are circulated to its members through their *Journal*. It will be appreciated, therefore, that the Royal Show is by no means the only, or even the main, activity of the Society. Nevertheless, it affords an excellent opportunity for showing and demonstrating the latest developments in all phases of farming and allows those interested in the many different branches of agriculture to meet on common ground.

A good example of the aid rendered by science to agriculture is furnished by the greatly improved insecticides and fungicides which have been made available to farmers recently. Another interesting development is the production of synthetic plant hormones which are used for the selective destruction of weeds among crops and either for the control, or stimulation of growth. It is, perhaps, appropriate therefore to commence our description of the exhibits at the Show by describing a new method of applying insecticides, which was exhibited on the stand of Messrs. R. A. Lister and Company, Limited, Dursley, Gloucestershire. The apparatus used is known as the Todd insectidal fog "applicator," and it is manufactured by the Lister-Todd Engineering Corporation Limited, Imperial House, Kingsway, London, W.C.2; it is illustrated in Fig. 1, on page 42, which shows the apparatus being used for clearing cowsheds. The Todd insectidal fog applicator, known from its initials as T.I.F.A., produces a dense fog impregnated with particles of insecticide or other chemical agent dissolved, or suspended, in oil or water. It consists virtually of three separate units: a liquid system, a petrol system, and an air system. The liquid system includes a chemical container which is connected by pipes to a pump which, in turn, delivers the liquid chemical through a control valve, or particle-size selector, to a liquid nozzle fitted to the distributor. In the petrol system, the petrol is pumped from a storage

tank through a control valve and is forced at a pressure of approximately 40 lb. per square inch through a burner into a combustion chamber supplied with air from a blower in the air system. The petrol is burnt in the combustion chamber and this results in a blast of hot air which leaves the combustion chamber through the distributor. The distributor is fitted with a polished stainless-steel cup into which, as previously mentioned, the liquid chemical is delivered. The hot air passes through four tangential holes in the cup and vaporises the liquid, imparting a swirling motion to it at the same time. The main air blast escapes to the atmosphere round the outside of the cup and this completes the process of vaporisation, the final result being a dense fog stream composed of particles of the desired size. The size of particle can be adjusted by the particle-size selector between the limits of 0·5 and 60 microns, and the manufacturers claim that the fog produced surrounds and clings to all objects in its path. The power for driving the two pumps and the blower is supplied by a small petrol engine. The weight of the complete unit is in the neighbourhood of 600 lb., while the overall length, breadth, and height are 32 in., 24 in., and 37½ in., respectively.

Another method of distributing insecticides, fungicides, etc., is to broadcast them in the form of a powder, a process known as crop dusting, and Messrs. E. Allman and Company, Limited, Birdham Road, Chichester, Sussex, were exhibiting their Speedesi crop duster. This utilises the tractor exhaust system for heating and distributing the powder and it is illustrated in Fig. 2, on this page, where it is shown fitted to a Fordson Major tractor. The powder is carried in the large conical hopper visible at the rear of the tractor and the exhaust is diverted by a two-way valve in the tractor exhaust system through a flexible metallic pipe to a Venturi tube situated at the base of the hopper. The powder is fed into the Venturi tube where it mixes with the exhaust gases and the mixture is then led to the distribution unit. The amount of powder delivered to the Venturi tube is regulated by a valve located in the base of the hopper and operated by a control rod extending through the cover of the hopper, while a graduated scale at the top of the hopper enables the operator to estimate the quantity of powder being used and regulate the flow accordingly. The frame to which the distribution unit is attached is adjustable for height, so that dusting can be carried out at all stages of crop growth, and when raised to its highest position the unit will pass over the top of the average gate post. The range of distribution units available covers a wide variety of crops and includes units capable of dusting fruit bushes and orchards.

The spraying of crops also plays an important part in the control of pests, and Messrs. Ransomes, Sims and Jefferies, Limited, Ipswich, included in their exhibits the latest design of their Agro sprayer. This machine is illustrated in Fig. 3, opposite, from which it will be seen that it is carried on a two-wheel trailer which, in turn, is hauled by an agricultural tractor. The power for operating the sprayer is obtained from the power take-off shaft of the tractor, which drives a low-pressure fan. The spray fluid is atomised in simple carburettor-type nozzles and is mixed with the large volume of air supplied by the fan, the subsequent mixture being discharged through the nozzles visible in Fig. 3; the machine illustrated, however, is fitted with only 7 nozzles whereas the machine exhibited had 9 nozzles. The latter are fitted into spring-loaded articulated legs spaced at 28 in. centres. The manufacturers claim that this system gives complete coverage for ground crops with only 10 gallons of fluid per acre.

A type of machine that is gaining steadily in popularity is the small power-driven scythe. These machines are very useful for cutting grass in confined and awkward spaces hitherto dealt with by hand scythes. Messrs. Charles H. Pugh Limited, Whitworth Works, Birmingham, were pioneers in the introduction of this type of mower, and this firm's exhibits included their well-known Atcosythe which has been redesigned completely. This machine was originally described in ENGINEERING, vol. 139, page 265 (1935), but since that time, has been improved considerably and the modern machine bears little resemblance to that described previously. The latest type of Atcoscythe, like its predecessor, is powered with a 148 cub. cm. Atco-Villiers, two-stroke petrol engine. The transmission, however, has been altered, and both the road wheel and the cutter bar are now driven by chains from the worm-reduction gearbox. The most interesting development, however, is the provision of two independent clutches, one for controlling the drive to the cutter and the other for controlling the drive to the road wheel. Adoption of this arrangement has made it possible to disconnect either the drive to the road wheel or the drive to the cutter at will, thus enabling the machine to be pushed through exceptionally heavy growth at a low speed. Another improvement worthy of mention is the provision of a foot starter in place of the more usual rope and pulley method of starting. The machine is exceptionally easy to handle, only three controls being fitted. These consist of two levers for operating the clutches referred to and they are located one on each guiding handle, while the third control is for regulating the speed. The handles are adjustable for height, and the weight of the complete machine is 191 lb.

Much ingenuity has been shown in the past regarding the design of horticultural tractors and, in the course of time, these small machines have been adapted to perform a wide variety of duties ranging from their original purpose, cultivation, to the driving of cutter bars and small generators. A newcomer to this field is the Atom tractor which was shown on the stand of the manufacturers, Messrs. Barford (Agricultural) Limited, Grantham, a subsidiary of Aveling-Barford, Limited. This tractor is one of the smallest made, yet it is capable of cultivating, grass cutting, hoeing, driving a small generator, and, by the addition of a two-

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

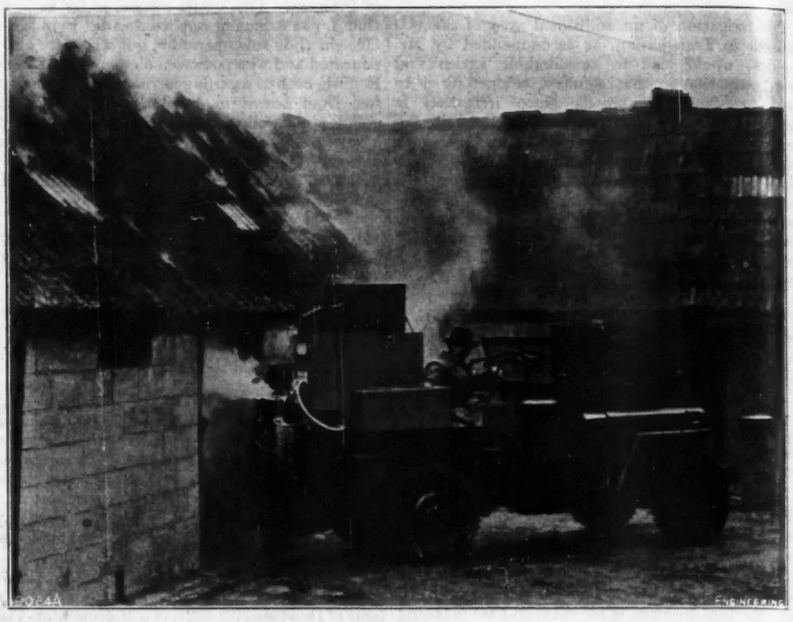


FIG. 1. INSECTIDAL FOG "APPLICATOR"; MESSRS. LISTER-TODD ENGINEERING CORPORATION LIMITED.

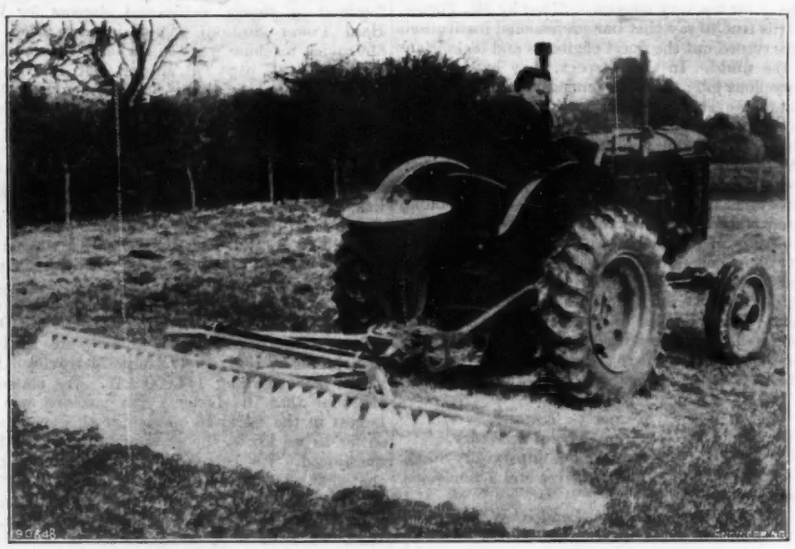


FIG. 2. "SPEEDESI" CROP DUSTER; MESSRS. E. ALLMAN AND CO., LIMITED.

EXHIBITS AT THE ROYAL AGRICULTURAL SHOW.

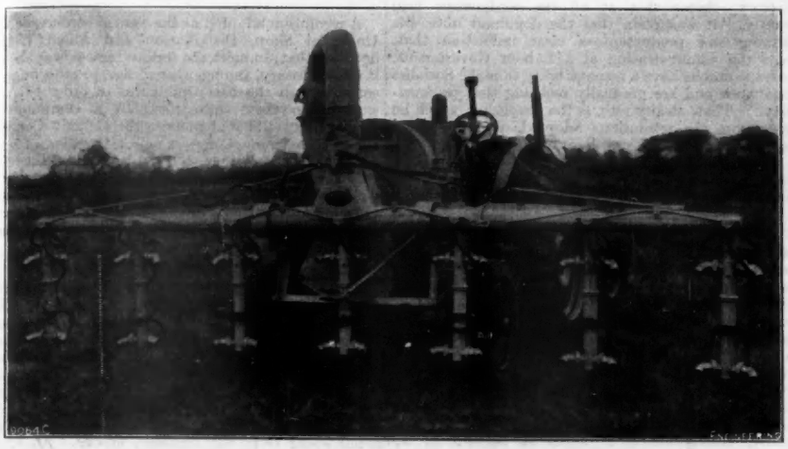


FIG. 3. "AGRO" SPRAYER; MESSRS. RANSOMES, SIMS AND JEFFERIES, LIMITED.

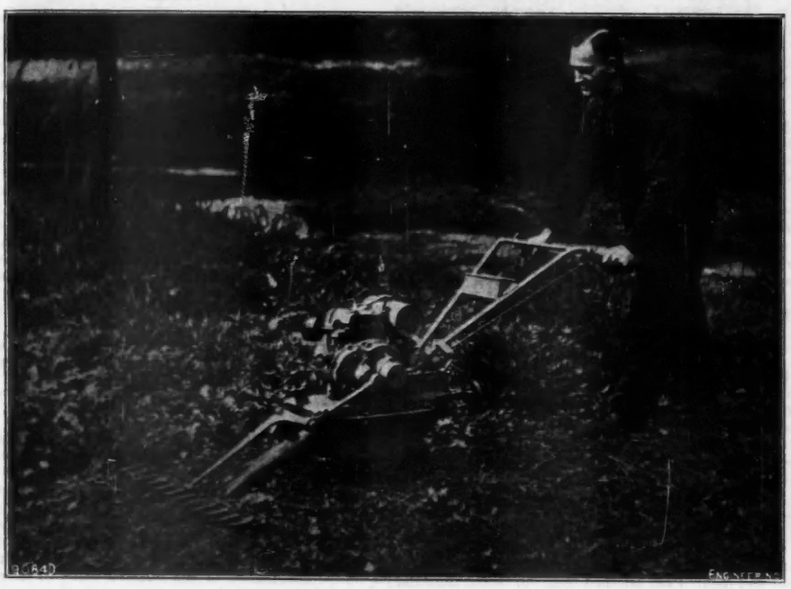


FIG. 4. "ATOM" HORTICULTURAL TRACTOR; MESSRS. BARFORD (AGRICULTURAL) LIMITED.

wheeled barrow, can be used as a 3-cwt. load carrier. The machine is illustrated in Fig. 4, on this page, where it is shown arranged for grass cutting. It is powered by a four-stroke air-cooled petrol engine, having a capacity of 98 cub. cm. The cooling is effected by an engine-driven fan, the drive to the fan serving also to drive a fly-wheel type magneto which is located between the fan and the engine. Lubrication is by splash, the oil being carried in a relatively large sump beneath the crank-case, while the fuel is carried in a tank situated behind and above the engine; the capacity of the tank is half a gallon. Under normal working conditions, the fuel consumption is in the neighbourhood of three-quarters of a pint per hour. The frame is pressed in one piece from mild-steel plate, while the handlebars are constructed from tubular steel and arranged so that they can be adjusted for height. The transmission to the single driving wheel is first through a reduction gearbox fitted with hardened and ground machine-cut gears, and then through a roller chain. In order to remove the shock of starting from the dog clutch, a friction shock clutch is incorporated in the transmission. Two types of driving wheel are provided for operating on grass and cultivated land respectively, the main spindle being designed for easy withdrawal and replacement. A power take-off is provided on the side of the reduction-gear casing and is visible in Fig. 4, where it can be seen fitted with a crank and connecting rod for driving the cutter bar. The weight of the complete unit is 177 lb., and the operating speed is in the neighbourhood of a mile per hour.

(To be continued)

IMPROVEMENTS AT LEICESTER-SQUARE TUBE STATION.—A new passage is now being constructed between the Northern Line and the Piccadilly Line platforms at Leicester-square Underground Railway station, London. The passage will improve the passenger interchange between the two lines and will give direct communication between the lower escalator landing of the Piccadilly Line and both platforms of the Northern Line at a central position. It will be a straight circular-section tunnel, 100 yards long, and, to break the monotony of a straight passage, is being constructed in various diameters, sections of 12 ft., 12 ft. 6 in. and 15 ft. being employed. The passage will be illuminated by fluorescent lighting. To carry out the work with the minimum interference to the public, a working shaft, 100 ft. deep, is being sunk from street level in Upper St. Martin's-lane, and, through this shaft, all the excavated material and the new material required for construction will be moved from and to the site. The work is expected to be completed by the end of the present year.

THE FULMER RESEARCH INSTITUTE.

A NOTABLE addition to the research facilities available in this country to the private inquirer was inaugurated on Wednesday, July 2, when Sir Stafford Cripps, M.P., President of the Board of Trade, formally opened the Fulmer Research Institute at Stoke Poges, Buckinghamshire. The Institute is a privately-sponsored non-profitmaking organisation, founded (in the words of its prospectus) "to provide a research centre where firms can use first-class facilities and a team of scientists of wide knowledge and experience to carry out research work on their behalf, the results of which remain their sole property"; and it is claimed to be the only establishment in the country where such confidential work can be carried out, the sponsor of it retaining full property in the results and in any patents arising from them.

The main building of the Fulmer Institute is a converted private house, standing in grounds of some 10 acres, situated about three miles to the north of Slough and about 20 miles from London. At present, it is equipped mainly for metallurgical work, but the apparatus already installed includes a certain amount suitable for mechanical testing, and it is expected that there will be further developments in this direction. The research envisaged is primarily the evolution of new processes and products, or the improvement of existing ones, thus supplementing the work of manufacturers' own laboratories, where limitations of equipment (or, perhaps, lack of the necessary privacy) may restrict the investigation of promising ideas. The charges levied will be framed to make the Institute self-supporting, and any excess of income over expenditure will be devoted to extending the range of its services. The founders claim for the Fulmer Institute that "it does not compete with any other research centre in this country, its nearest parallels being the great American organisations, such as the Battelle and Mellon Institutes."

The accommodation in the main building comprises, on the ground floor, a conference room, the administrative offices, and an office for the Director of Research, Mr. E. A. G. Liddiard, M.A., F.I.M.; the library, canteen and various staff rooms; physics and X-ray laboratories, the engineering laboratory, and the creep-test room. On the first floor are the laboratories devoted to metallography (with an etching and polishing room adjoining), corrosion and plating, spectrographic analysis, chemical investigations, and high-vacuum work. There are also a balance room, a general study and several smaller studies for the use of the staff in preparing reports, and well-equipped photographic dark-rooms. Adjacent to the main building a separate steel-framed building, brick-faced, has been erected to house the engineering workshops, which include a machine shop, and experimental casting and heat-treatment laboratories.

The equipment at present installed includes, in the chemistry section, apparatus for absorptiometric, potentiometric and microchemical analysis, metal extraction and refining, and corrosion-testing, plating and finishing. The physics laboratories are equipped for spectrographic analysis; X-ray analysis, (using a Metropolitan-Vickers crystallographic unit); and mechanical testing, for which there are provided Vickers, Rockwell and Brinell hardness testers, an Izod impact tester, two Dennison creep-test units, a 10-ton Avery machine for tensile, compression and bend tests, an Avery duplex Wöhler fatigue-testing machine, and a 30-cwt. Haigh fatigue-tester. In the metallurgy department there is a Bausch and Lomb metallograph for examining and photographing specimens at magnifications up to 2,500; a high-frequency induction vacuum furnace, an indirect arc resistance furnace, sand-testing equipment, etc., a kiln for firing refractories, and various heat-treatment furnaces.

Pending a supply of town gas, any gas supplies needed are provided in cylinders, but the laboratories are piped for gas. Electric power is available throughout, the main supplies being three-phase 50-cycles at 415 volts and single-phase at 230 volts. Direct current is provided from rectifiers in the corrosion, etching and polishing, and engineering laboratories. Much of the miscellaneous apparatus has been constructed in the Institute workshops, which it is expected to use to an increasing extent in providing special equipment for particular researches. Several creep-testing machines are under construction at present. Eventually the shops will contain five lathes, four drilling machines, a shaper, a universal grinder and a tool-post grinder, a universal milling machine, saws, bending rolls, and welding plant. A small workshop for the construction and maintenance of instruments is also provided. It may be mentioned, in conclusion, that arrangements can be made for sponsors of researches to send members of their staffs, or other nominees, to work at the Institute, so that they may take part in the development of new processes which, later, they may have to operate on a production basis.

NOTES ON NEW BOOKS.

Practical Plastics Illustrated. Edited by PAUL I. SMITH. Odhams Press, Limited, Long Acre, London, W.C.2. [Price 10*s.* 6*d.*]

THE interaction between the advances in and the trends of the plastics industry, as regards both the satisfactory qualities of the finished products for their intended purposes, and the choice of raw materials to suit desired methods of fabrication, provides sufficient justification for this instructive volume which comprises an orderly series of articles contributed by 12 experts, each of whom has experience in one or more specialised sub-divisions of modern practice. Additional justification could be claimed, nevertheless, in respect of the introductory chapters, dealing succinctly with the physical and chemical characteristics of plastic substances, and with the position of plastics among the world's industries, for they form a background against which the succeeding technological descriptions can be reviewed with enhanced clarity and realism. A somewhat similar objective underlies, no doubt, the useful survey of the qualities and performance demanded by standard specifications for plastics, and a critical account of the associated practices in mechanical and electrical testing. On this foundation, and with the help of a large number of excellent illustrations, Mr. Paul Smith's team of authors expound the technologies entailed in the design and manufacture of moulds; in moulding by the compression, injection and transfer methods; in extrusion operations by the use of dies; in "rubber bag" forming; in sheet production; and in the manufacture and fabrication of laminates and plastic-impregnated woods.

Saws and Sawing Machinery. By ERIC N. SIMONS. Sir Isaac Pitman and Sons, Limited, Parker-street, London, W.C.2. [Price 15*s.* net.]

THE saw is one of the oldest types of hand tool, yet the literature of saws and sawing is scanty in the extreme and, so far as we are aware, Mr. Simons is justified in his belief that this book is the first to attempt a survey of all kinds of saws and sawing machinery. He has done his work well, producing a book which undoubtedly will rank as a reference work for some time to come; but it is to be hoped that further editions will follow, because a widening of interest should bring additional information from practising "saw doctors," makers and users, and it would seem that there is scope for research in various parts of this field. Meanwhile, the book can be recommended as a really useful contribution to technical literature, containing illustrated descriptions of a considerable variety of hand and machine saws, and a great deal of thoroughly practical information on selection, application and maintenance.

Southampton Docks: 1947 Handbook of Rates, Charges and General Information. Southern Railway Docks and Marine Department, Manager's Office, Southampton. [Price 1*s.*]

THE somewhat mundane, not to say unappetising, subtitle of this official brochure does it much less than justice, for the "general information" bulks larger than the more mercenary rates and charges portions, but contains a large amount of data, not all readily accessible elsewhere, about the construction, operation and current equipment of the Southampton dock system. There is also an excellent folding map of the dock estate. There are also reviews of the historical development of the docks, their pre-war trade, and their all-important war-time activities, which included the building, in a dry dock, of 12 of the 4,000-ton caissons for the "Mulberry" harbour, and the construction, completion or repair of many other vital components of the Normandy invasion equipment.

Ships: A Study in Modern Shipbuilding. By J. S. REDSHAW. Published for Vickers-Armstrongs Limited, by Frederick Muller, Limited, 29, Great James-street, London, W.C.1. [Price 10*s.* 6*d.* net.]

"POPULAR" books on highly specialised subjects are not often dependable in their technical detail, but Messrs. Vickers-Armstrongs ensured accuracy in the case of this well-written and handsomely illustrated work by entrusting its authorship to their principal naval architect. The greater part of the book is devoted to a sort of "sightseeing" tour of the Barrow shipyard and engine works, taking the various stages of construction of a typical ship and her machinery in their proper sequence; but there is also an introductory section, mainly historical, and supplementary chapters dealing with the other establishments of the firm and with the war work of the whole organisation. As indicated above, the illustrations are of particularly high quality, and include 12 direct-colour photographs by Mr. P. G. Hennell which are a credit alike to the photographer and to the printers.

LABOUR NOTES.

WRITING in the *Monthly Trade Review* of the United Patternmakers' Association, Mr. Beard, the general secretary, claims that at all the conferences held recently, "it was plain that the dominant note was planning and production—a clear indication that, under the administration of a Labour Government, the trade unions have a responsibility to make Socialist plans work and are gradually realising that responsibility." That, at any rate, is the conclusion which he draws from the resolutions adopted, provided these have the backing of the rank and file. On that point, he admits that "the number of unofficial strikes in vital services in the London area of recent date gives cause for some doubt."

"The functions of trade unions," he goes on to say, "must change, even if the changes are not at once perceptible. The alternating fat and lean years of the past decade produced a trade-union policy of restriction— a policy which was designed to protect the workers against reductions in wages, and in earnings produced by extra effort, and, above all, to secure and maintain employment. With a surplus of men outside the factory gate seeking employment, the position of those inside was none too secure, particularly in the lesser skilled occupations. To-day, there is much work to do, with too few workers to do it. Consequently, the standard of living is higher. It is, however, crystal clear that to increase that standard, or even to maintain it, production must be increased in all industries, and to do that planning and mechanisation are necessary. But in planning production and increasing it, many workers are greatly concerned, not only in performing the work, but in relaxing certain trade-union principles, and, therefore, should have a greater share in management."

Mr. Beard recommends as a step in that direction the setting up, in all industries, of production committees on which workers are represented. "It may be necessary," he writes, "to sub-divide these committees. In the patternmaking industry, for instance, it is obviously quite possible for greater consultation to take place between management and men, particularly in the larger shops, for only patternmakers understand the intricacy of their job, and should, therefore, have a share in planning and management. Such a consultative committee could not only iron out production difficulties, but could ensure that the effort made would be rewarded in accordance with the recent agreement."

But, he continues, "there are still employers who will not reward output, because, they claim, they cannot measure effort in our industry, particularly in the smaller shops; but, I fancy, that if our members gave just the amount of work for which they were paid, the same employers would be loud in their complaints that output had fallen. They cannot have it both ways. These committees could also deal with apprentices, their training, and even their ratio to journeymen, for there are many problems peculiar to our craft to be dealt with, and a responsibility assumed by our members would, in the ultimate benefit both management and men. I am satisfied from our recent informal conference with the employers on our wage settlement, that many employers are recognising effort and that relations are cordial in the main. The fact that some employers have still the pre-war mentality is not the fault of those at the top."

In May, 75 members were enrolled by the United Patternmakers' Association, making the total membership 15,230. Superannuation benefit was paid to 836 members.

The Agricultural Wages Board for England and Wales agreed last week to increase the minimum wage for men from 80*s.* a week to 90*s.* a week, with corresponding adjustments for women and juveniles. In a communication issued for the Board, it was stated that members had hoped that the decision reached about a year ago—to raise the minimum wage to 80*s.*—would be regarded as satisfactory, coupled with what had already been done about reduction of hours, increased holidays and overtime rates; but they had had to consider the alterations since in the general level of wages. "We have reached the conclusion," the statement continued, "that in view of the increases which have taken place in other industries in the past year, and of the reduction of hours which, in effect, means a corresponding increase in wage rates, there is a case for an increase in the agricultural minimum wage, and accordingly, the appointed members would be prepared to support an increase in the minimum for men from 80*s.* to 90*s.*, with corresponding adjustments for women and for juveniles of both sexes. In the case of women, aged 21 and over, the wage would be increased from 60*s.* to 68*s.*, except in a few areas." The Board is to meet again on August 19 to consider any objections, and to make an order giving effect to the new rates and changes.

A resolution adopted at the annual conference of the Union of Shop, Distribution and Allied Workers, declared that, to meet the serious man-power shortage, it was necessary, among other things, to raise wages and conditions in the basic industries in order to attract workers to these industries. In a communication addressed to affiliated unions, the General Council of the Trades Union Congress reject the idea of such a national wages policy. They say that they have "no intention of seeking the adoption of any policy which would substantially modify the present position, or would impose limits upon the rights of unions, either within the basic industries, or in other industries, to engage in collective bargaining."

At its closing session at Hastings, the National Committee of the Amalgamated Engineering Union considered a resolution relating to the constitution of the Trades Union Congress General Council sent in by Yorkshire and Lincolnshire. The resolution expressed the view that, owing to the ever-increasing duties and responsibilities of the General Council, all, or part, of its membership should be full-time members elected by the Trades Union Congress on nominations from the affiliated unions. An amendment was carried, accepting the principle but referring the matter to the executive council of the union.

The Court of Inquiry appointed by the Minister of Labour and National Service to consider the applications of the three trade unions of railwaymen for increases of wages and a shorter working week have recommended an increase of 7*s.* 6*d.* a week in the basic rates of all adult workers, a 44-hour week without loss of pay for the traffic grades, and a 42-hour week for the clerical staff, also without loss of pay. Members of the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen have had, up till now, a 48-hour week, and members of the Railway Clerks' Association, a week ranging from 38 hours to 48 hours. The wages application was for an increase of 20*s.* a week—or its equivalent in the case of salaried staff—and the new rates are, the award states, to come into operation as from the beginning of the current month. The Court's recommendation was described "as on a short-time basis and as an interim measure." Both the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen have "reluctantly" accepted the award, and, no doubt, the Railway Clerks' Association will follow their example in due course.

It is pointed out in the report that, in framing its recommendations, the Court have had regard to the special circumstances of the railway industry at the present time and that the findings are not intended to serve as a basis for a general upward movement of wages. Among the other conclusions is a suggestion that there should be comprehensive examination of the grading of railway workers, with a view to the more accurate assessment of the relative value of different types of work, and re-arrangement of inter-grade margins so that "adequate incentive may be given for the acceptance of higher responsibility consequent on promotion. The Court does not recommend that there should be any increase in the rates for Sunday work or for work on Saturday afternoons and evenings.

The report of the Committee set up to consider the Double Day-Shift System, issued last week as a White Paper, recommends that as a normal arrangement, the hours should fall between 7 a.m. and 11 p.m. At present they are from 6 a.m. to 10 p.m. The wider use of the system in factories, it is stated, could make an important contribution to the economic well-being of the country, although it must involve some segregation and dislocation of family life. There would also be other social and educational disadvantages for the workers. There is need, however, for the system, the Court believes, as a normal and permanent feature.

In the course of the discussion in the House of Commons last week on the Vote for the Ministry of Labour and National Service, Mr. Isaacs said that the Government were asking industry to examine methods of payment by results and to adopt the practice where possible. It was not the Government's job to say to industry that it must adopt this or that form of incentive. Dealing with the "call" for the regulation of wages, Mr. Isaacs observed that it seemed only to come when wages were going up. "Once," he declared, "you get the Government fixing wages all your general elections will be fought on the plea, 'Vote for me, and I will get you ten bob more.'"

ALL-WING AIRCRAFT.

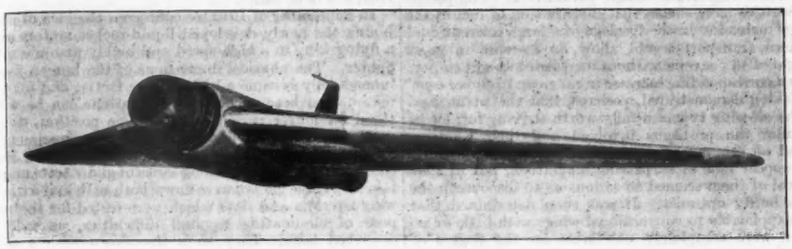


FIG. 5. NORTHROP ALL-WING FLYING BOMB.

FIG. 6. PILOT-CONTROLLED FORM OF FLYING BOMB.

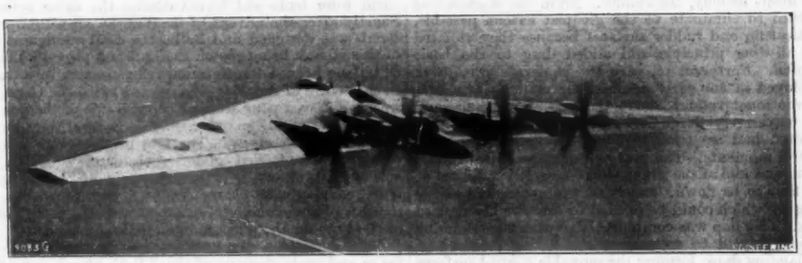


FIG. 7. NORTHROP XB-35 ALL-WING HEAVY BOMBER.

THE DEVELOPMENT OF ALL-WING AIRCRAFT.*

By JOHN K. NORTHROP.

IN considering the development of all-wing aircraft I would like first to distinguish between all-wing and tailless aeroplanes. By all-wing aircraft I mean a type of aeroplane in which all of the functions of a satisfactory flying machine are disposed and accommodated within the outline of the aerofoil itself. We have not, as yet, built any pure all-wing aircraft; all have had some excrescences, such as propellers, propeller-drive shaft housings, jet nozzles, gun turrets, and the like. We have built, however, a number of aeroplanes in which the minimum parasite drag coefficient has been reduced to approximately half that ordinarily attained in the best conventional aircraft of like size and purpose, and in some of the designs completed and tested the excrescences and variations from the aerofoil contour have been responsible for less than 20 per cent. of the minimum aeroplane drag. There are startling gains to be made in the aerodynamic and structural efficiency of an all-wing type, provided that certain basic requirements can be fulfilled by the type in question.

First, the aeroplane must be large enough for the all-wing principle to be utilised fully. This is a matter closely related to the density of the elements comprising the weight empty and the useful load to be carried within the wing. At times, the dimensions of the average human body may be the limiting factor but, ordinarily, in the larger types of transport or bombardment aircraft, it will be found that excessive sizes are not necessary to secure, within a wing of reasonable thickness ratio, adequate volume for a commercial cargo or bomb load together with the necessary fuel. The extremes explored and satisfactorily flown to date in our experience range from a flying bomb having a span of 29 ft., to the 172-ft. XB-35 long-range bomber aeroplane, and these two aircraft are shown to scale in Fig. 1, on page 36. The XB-35 is considerably larger than would be necessary to provide ample space for passenger and crew comfort and ample volume for payload, be it cargo or bombs. It was designed larger than necessary because we desired to keep the wing loading comparatively low in this first large experimental venture. It has a normal gross weight of 165,000 lb., an overload gross weight of 221,300 lb., and sufficient volume within the wing envelope for the maximum gross weight at take-off to be increased to over 300,000 lb., rather more than half of which could be devoted to bombs, fuel and miscellaneous payload.

The second basic requirement is that the all-wing aeroplane shall be designed to have sufficient stability and controllability for practical operation as a military or commercial aeroplane. We believe this requirement has been met fully by hundreds of flights completed with this type, and we are convinced of its practicability after having built a dozen different aeroplanes embodying many different configurations of the all-wing principle.

In comparing all-wing and conventional types, we may fairly assume that spans of comparative aircraft having the same gross weight are equal. As a further simplification we may, for the moment, neglect compressibility effects in our comparison of the advantages of all-wing and conventional types of large bombardment or transport aircraft having maximum velocities up to approximately 500 m.p.h. Based on these assumptions and on the following proved data on the all-wing type, a comparatively simple analysis of advantages may be made. The ratio of the minimum parasite drag coefficient ($C_{D_{min.}}$) for all-wing aeroplanes to that for conventional types is approximately 1 to 2. Minimum drag coefficients for a number of large bomber and transport aircraft, such as the B-29, B-24, C.54, and others, average approximately 0·023. The minimum drag coefficients for several all-wing types have been measured, both in model and full-scale configurations, and vary from less than 0·010 to about 0·0113. The ratio of maximum trimmed lift coefficients ($C_{L_{max.}}$) for all-wing to conventional types is approximately 1·5 to 2·3. The latter figure is typical for the conventional aircraft mentioned previously. The former is readily attainable and may be subject to considerable improvement from the use of several types of high-lift devices yet to be proved.

For comparable aeroplanes of the same span and gross weight the selection of the required wing area will depend either on flight conditions, including take-off without flaps, or landing conditions. If the flight conditions govern, the ratio of required wing areas of all-wing to conventional aircraft will be 1 to 1, because the two wings are equally effective except under conditions of maximum lift. If landing conditions govern, assuming the same landing speed in each case, the ratio will be 2·3 to 1·5. If take-off with partial flap deflection governs, the ratio will be somewhere between these two figures. In large all-wing bombers and transports, and to a growing extent in conventional long-range transports as well, the ratio of gross weight at take-off to landing weight will approach 2 to 1. Therefore, flight conditions are likely to govern the selection of wing area more than landing conditions. In the following calculations both extremes are used as indicative of the range of advantage to be gained by the use of the all-wing configuration. Referring to equation (1) below, it may be seen that the total minimum parasite drag of the all-wing aeroplane in terms of the conventional aeroplane will vary from 50 per cent. if flight conditions govern, to 77 per cent. if landing conditions govern. In this equation $(D_p)_a$ and $(D_p)_c$ represent the parasite drags of all-wing and conventional aeroplanes, while S_a and S_c represent the respective wing areas.

$$\frac{(D_p)_a}{(D_p)_c} = 0{\cdot}50 \times \frac{S_a}{S_c} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$= 0{\cdot}50 \times 1{\cdot}0 = 0{\cdot}50 \text{ (flight condition)}$$

$$= 0{\cdot}50 \times \frac{2{\cdot}3}{1{\cdot}5} = 0{\cdot}77 \text{ (landing condition).}$$

It is a well-known fact, based on the Breguet range formula, that, with conventional reciprocating engines and propellers, the speed for maximum range is approximately that at which parasite drag and induced drag are equal. Therefore, at the same cruising speed as the conventional aeroplane, the all-wing type will require from 25 per cent. to 11½ per cent. less power, as shown in equation (2), below, and with the same amount of fuel will fly from 33 per cent. to 13 per cent. farther, as indicated by equation (3). In these equations, P represents power required, D total drag, V aeroplane velocity, and R the range, the suffixes a and c again denoting the all-wing and conventional configurations.

$$\frac{P_a}{P_c} = \frac{D_a}{D_c} \times \frac{V_a}{V_c} = \frac{D_a}{D_c} \text{ (at equal speeds) . (2)}$$

$$D_a = (D_i)_c + (0{\cdot}50 \text{ to } 0{\cdot}77) \times (D_p)_c$$

$$= (1{\cdot}5 \text{ to } 1{\cdot}77) \times (D_i)_c$$

$$D_c = 2\,(D_i)_c.$$

Therefore

$$\frac{P_a}{P_c} = \frac{1{\cdot}5}{2} \text{ to } \frac{1{\cdot}77}{2} = 75 \text{ per cent. to } 88{\cdot}5 \text{ per cent.}$$

$$\frac{R_a}{R_c} = \frac{P_c}{P_a} = \frac{1}{0{\cdot}75} \text{ to } \frac{1}{0{\cdot}885} = 133 \text{ per cent. to } 113 \text{ per cent. . (3)}$$

If the all-wing aeroplane is operated at its most economical speed, instead of the most economical speed of the conventional aeroplane, it will fly 19 per cent. to 7 per cent. faster and the range will be from 41 per cent. to 14 per cent. greater with the same amount of fuel, as indicated in equation (4) below.

$$\frac{R_a}{R_c} = \sqrt{\frac{(C_{D_p}\,S)_c}{(C_{D_p}\,S)_a}} = \sqrt{\frac{1{\cdot}0}{0{\cdot}5}} \text{ to } \sqrt{\frac{1{\cdot}0}{0{\cdot}77}} = 1{\cdot}41 \text{ to } 1{\cdot}14 \quad (4)$$

* Thirty-fifth Wilbur Wright Memorial Lecture, delivered before the Royal Aeronautical Society, London, on Thursday, May 29, 1947. Abridged.

and

$$\frac{V_a}{V_c} = \sqrt[4]{\frac{(C_{Dp}\ S)_c}{(C_{Dp}\ S)_a}} = \sqrt[4]{\frac{1{\cdot}0}{0{\cdot}5}} \text{ to } \sqrt[4]{\frac{1{\cdot}0}{0{\cdot}77}}$$

$$= 1{\cdot}19 \text{ to } 1{\cdot}07.$$

Under high-speed conditions with any type of power plant, the parasite drag becomes a much larger percentage of the total drag than for cruising conditions with reciprocating engines. At high speed the parasite drag may account for 80 per cent. or more of the total, while the induced drag drops to 20 per cent. or less. Using an assumed figure of 80 per cent. parasite drag, which is probably correct to ± 10 per cent. for most aircraft, the power required to drive the all-wing aeroplane at the same speed as the conventional aeroplane will be from 40 per cent. to 18½ per cent. less, as shown in equation (5) below, and the range, at the high speed of the conventional aeroplane, will be from 66 per cent. to 22 per cent. greater, as indicated in equation (6).

$$\frac{P_a}{P_c} = \frac{D_a}{D_c} \text{ (at equal speeds)} \quad . \quad . \quad . \quad . \quad (5)$$

$$D_a = (D_i)_c + (0{\cdot}50 \text{ to } 0{\cdot}77) \times (D_p)_c$$

$$= (D_i)_c + (0{\cdot}50 \text{ to } 0{\cdot}77) \times (D_i)_c \times 4$$

and $D_c = (D_i)_c + (D_i)_c \times 4$

Therefore

$$\frac{P_a}{P_c} = \frac{1 + (2 \text{ to } 3{\cdot}08)}{1 + 4} = 60 \text{ per cent. to } 81\tfrac{1}{2} \text{ per cent.}$$

$$\frac{R_a}{R_c} = \frac{P_c}{P_a} = \frac{1{\cdot}0}{0{\cdot}60} \text{ to } \frac{1{\cdot}0}{0{\cdot}815} \quad 166 \text{ per cent. to}$$

122 per cent. (6)

As turbo-jet and turbo-propeller power plants both operate at relatively high speed for best fuel economy, the advantages of the all-wing configuration, when used in combination with these power plants, will approach closely the above figures for maximum range as well as high speed. These advantages are based on the simple aerodynamic values obtained with all-wing aeroplanes; namely, that $C_{D_{min.}}$ equals 50 per cent. of the conventional, and $C_{L_{max.}}$ equals 65 per cent. of the conventional. The probabilities are that the minimum parasite drag can be reduced, within a comparatively short time, to about 40 per cent. of the conventional figure and that the maximum trimmed lift coefficient ($C_{L_{max}}$) may be increased, within a similar short time, to at least 75 per cent. of conventional values.

One of the most interesting devices for increasing maximum lift is, of course, the judicious use of boundary layer control in conjunction with turbo-jets or gas turbines. Another involves the development of a better combination of low pitching moment flaps and trimming devices, and model configurations tested up to this time, employing such methods, have shown improvements of 0·1 or 0·2 C_L over the figure now used of 1·5. A third possibility of a rather unconventional nature remains to be proved in the all-wing aeroplane. This consists of placing the centre of gravity behind the aerodynamic centre of the wing, eliminating inherent longitudinal stability by so doing, and replacing this characteristic, which heretofore we have always considered as an essential to satisfactory aircraft design, by highly reliable automatic pilots which take over the function of stability from the airframe and may perhaps do a better job of maintaining the proper attitude than the present classical method. While unconventional and possibly somewhat horrifying to those unaccustomed to the idea, it may have practical application to very large aircraft where the pilot's skill and strength are largely supplanted by mechanical means, and wherein the pilot controls the mechanism which in turn places the aeroplane at the desired attitude. If the centre of gravity is located aft of the aerodynamic centre the aeroplane will trim at a high angle of attack with the flaps or elevator surfaces deflected downward rather than upward from their normal position, thereby increasing the camber and rendering the whole aerofoil surface a high-lift device. It is possible that trimmed lift coefficients in the order of 2·0 may be achieved by this method, and experiments with such a device on conventional aircraft show that the centre of gravity may be displaced at least 10 per cent. of the mean aerodynamic chord aft of a normal position without any uncomfortable results in the flying characteristics of the aeroplane.

There are other major advantages of the all-wing type which cannot be evaluated so definitely, but which can and do contribute appreciably to improvement in efficiency and range. Two of these are the elimination of jet-tail surface interference, and the possible elimination of wing-tail surface shock-wave interference. The third, and the most immediately applicable to designs of the near future, is the improved adaptability of all-wing types to the distribution of major items of weight empty and useful load over the span of the wing. This results in substantial savings in structural weight which have important effects on the ratio of gross weight at take-off to landing weight. An analysis of the range formula indicates that this ratio is one of the most important range parameters. Competent authorities have shown that distribution of fuel in the wings instead of in the fuselage of a large conventional modern transport would allow an increase in gross weight of 16 per cent. without increase of weight empty, with a corresponding increase in range up to 30 per cent.

Having demonstrated, perhaps, that the advantages of the all-wing type are fully worth striving for, let us consider the problems involved and their solution. Based on our present experience, these difficulties do not appear now of surpassing magnitude, but in 1939 several of them seemed so serious as to discourage the most hardy optimist. It was soon determined that data applicable to conventional wings with little or no sweep were completely unreliable for the degree of sweepback required in practical all-wing designs, and that a whole new technique had to be developed to determine the limits within which taper ratio, sweepback and thickness ratio could be combined for satisfactory results. All these variables were explored in a series of wind-tunnel models, and when a reasonably satisfactory group of configurations had been determined, it was decided to build the first piloted flying wing, the N 1 M (Northrop Model 1 Mockup). Because of the many erratic answers and unpredictable flow patterns which seemed to be associated with the use of sweepback, it was decided to try to explore most of these variables full scale, and the N 1 M provided for changes in planform, sweepback, dihedral, tip configuration, location of centre of gravity, and control-surface arrangement. Most of these adjustments were made on the ground between flights; some, such as the location of centre of gravity, were undertaken by the shift of ballast during flight. It is an interesting commentary on the comparative ease with which the basic problems of controlled flight were solved to note that no serious difficulty was experienced in any flight attempt, or with any of the various configurations used.

From the inception of the work, longitudinal and lateral controls were combined in the "elevon," a word coined to designate the trailing edge control surface members which operate together for pitch control and differentially for roll control. At no time during early tests did control about the pitch or roll axes give any appreciable difficulty. The control which was expected to cause the least difficulty gave the most, namely, the rudder. From the start it was decided to eliminate to the greatest extent possible, vertical fin and rudder surfaces because they violated the all-wing principle and added drag to the basic aerofoil. Furthermore, with the moderate sweepback employed in our early designs, the moment arm of a conventional rudder about the C.G. was small, and an excessively large vertical surface would have resulted had we tried to achieve conventional yaw-control moments. The best and most practical rudder found was one of the simplest in conception and one of the first to be flown, namely, a plain split flap at the wing tip which could be opened to produce the desired drag. This flap was combined later with the trimming surface needed to counteract the diving moment of the landing flaps, forming the movable control surfaces at the wing tip of the XB-35, shown in Fig. 2, on page 36.

The N1M was first flown in July of 1940 and about a year was occupied in a combination of aerodynamic tests and attempts to solve engine-cooling problems. As soon as good sustained flight demonstrations could be made on schedule, the Army Air Forces took active interest in the programme and we were encouraged to investigate the application of the all-wing principle to large bomber aircraft. To this end it was decided to construct four scale models of a larger aeroplane. These were designated N9M (Northrop Model 9 Mockup) and except for the power plant and propeller arrangement, they duplicated the aerodynamic configuration of the proposed XB-35 aeroplane. This design is shown in Fig. 4 on page 36. The first of these aircraft was test flown on December 27, 1942, and had completed about 30 hours of test flying with a pilot and, sometimes, an observer, when it crashed, killing the pilot. The machine had been on a routine test flight across the desert away from its base, and was out of sight of technically qualified observers at the time of the accident. However, all evidence pointed to a spin, and the attitude of the aeroplane on the ground indicated auto-rotation at the time of impact. This loss was a serious setback and work was started immediately to re-check the spin characteristics of the aeroplane in a spin tunnel. It was determined later, both in the tunnel and in flight, that recovery was good, although somewhat unconventional, requiring aileron rather than elevator action, but that the spin parachutes which had been attached to the aeroplane for the low-speed stalling and stability tests then in progress, were ineffective as to size and improperly located. Subsequent models, over hundreds of flights, gave no trouble. The low-speed stall and spin tests with rear centre of gravity positions were accomplished without further difficulty and the N9M proved an invaluable test bed in which various control configurations could be tried out in detail.

In September of 1942 we conceived the idea of combining the newly developed liquid-rocket motors with a flying wing in a high-speed and highly manœuvrable fighter. The physical dimensions of the human frame immediately became a limiting size factor, and for this reason, and because higher accelerations can be withstood for longer periods in the prone position, it was decided to place the pilot prone. Three experimental, full-size glider versions of this little aeroplane were completed rapidly and a long series of glider tests undertaken. These gliders were flown both with and without wing-tip slots and slats which were tested for the purpose of eliminating tip-stall difficulties, as will be described later. They were also flown with a wide variation in vertical fin area, to determine the amount necessary for various flight conditions. The airframe was considered suitable for the purpose intended long before the rocket motors had been developed to a degree of reliability considered safe for use, but finally a small motor having about five minutes' duration was installed and several rocket-powered flights were accomplished.

As no alternative rocket engine was available, it became necessary to modify the design to incorporate turbo-jet power plants, and the second of the XP-79 series, called the XP-79B, was fitted with two Westinghouse B-19 turbo-jets. The finished aircraft is illustrated in Fig. 3, on page 36. It was airborne first on September 12, 1945, and the take-off for this flight was normal. For 15 minutes the aeroplane was flown in a beautiful demonstration, and the pilot indicated increasing confidence by executing more and more manœuvres of a type that would not be expected unless he were thoroughly satisfied with the behaviour of the aeroplane. After about 15 minutes of flying the aeroplane entered what appeared to be a normal slow roll, from which it did not recover. As the rotation about the longitudinal axis continued the nose gradually dropped, and at the time of impact the aeroplane appeared to be in a steep vertical spin. The pilot endeavoured to leave the aircraft but the speed was so high that he was unable to clear it successfully. Unfortunately, there was insufficient evidence to determine the cause of the disaster.

Several other all-wing aircraft and variations of them were built and tested during the same period. Shortly after the advent of the V-1, an all-wing flying bomb was designed and built, the final configuration of this missile being shown in Fig. 5, on page 45. This aeroplane housed the German V-1 resonator in a duct in the centre of the wing and carried twice the German warhead in cast wing sections on each side of the power plant with fuel in the outer wings. Several were built and flown successfully. The first of these was tested as a pilot-controlled glider with success. That it was small is shown by Fig. 6, on page 45, but it had quite good flight characteristics, was flown on a number of occasions, and demonstrated the suitability of the type for the purpose intended.

During all this development and testing of other types and scale versions of the XB-35, the design and construction of the big aircraft had been under way. The problem of control-surface actuation on the big bomber involved the development and testing of a complete hydraulic control system, as none of the aerodynamic boosts or balances developed and tested in the N9M models had proved satisfactory. The system used in the XB-35 employs small valves which are sensitive to comparatively minute movements of the control cable and which, when displaced, permit large quantities of oil to flow into the actuating cylinders. This arrangement eliminates any pilot "feel" of the load on the control surfaces unless a deliberate arrangement for force feedback is made. Rather than undertake this latter step, a comparatively simple force mechanism, which is sensitive to accelerations and airspeed, was developed. This device gives the pilot a synthetic feel of the aeroplane which can be adjusted in intensity to anything he likes, and which has proved satisfactory in flight.

The XB-35 was first flown from Northrop Field to the Muroc Army Test Base in June, 1946. The first flights indicated no difficulty with the airframe configuration. Indications of trouble with propeller-governing mechanisms, however, were discerned at an early date, and it was soon discovered that flights of any substantial duration could not be accomplished because of oil leakage in the hydraulic propeller-governing system. On the last flight, difficulty with both propellers on one side caused a landing with asymmetrical power, which was accomplished without trouble. The XB-35 is shown in flight in Fig. 7, on page 45, but, so far, it has not had sufficient time in the air fully to demonstrate its ability to meet the design performance guarantees.

Let us now turn to considerations of stability and control of the all-wing aeroplane. They are quite

different from those of conventional types and, unless understood reasonably well, may lead to discouragement at an early date concerning projects well worth further evaluation. In any aeroplane the primary parameter determining the static longitudinal stability is the position of the centre of gravity with respect to the centre of lift or the neutral point. In an all-wing aeroplane, the elimination of the tail makes the problem of balance somewhat more critical, but not excessively so. Unfortunately, for any given aeroplane, the neutral point does not ordinarily remain fixed with variations of power, flap-setting or even lift coefficient, so that the after centre of gravity limit for stability is often prescribed by some single flight condition. In our experience with tailless aircraft, the critical condition has always occurred for power-off flight at angles of attack approaching the stall.

The pitching instability of a swept wing at high lift coefficients is now a familiar phenomenon. The complete mechanisms involved, however, are still somewhat obscure. There are apparently two opposing effects which are of prime importance. They are the tendency for sweepback to increase the relative tip loading and, by creating a span-wise pressure gradient, to promote boundary-layer flow towards the tip. On a plain swept-back wing the latter effect apparently nullifies the former, so that there occurs in the tip portion of the wing a gradual decrease in effective section lift-curve slope with a resulting progressive decrease in stability. This effect is indicated in Fig. 8, on this page, which also shows that the tip, in these circumstances, never stalls completely, as evidenced by the stable pitching moments occurring at the maximum lift coefficient. On the other hand, as illustrated in Fig. 9, the addition of end plates will prevent, to a large extent, the effects of span-wise flow, thereby straightening the pitching moment curve but producing the normally-expected tip stall, as evidenced by the strongly unstable moments in the vicinity of the maximum lift coefficient. Thus, any modification to the basic wing which affects the span-wise flow will have a noticeable effect on the pitching behaviour at high lift coefficients. In the case of the XB-35, the propeller-shaft housing acts to inhibit span-wise flow and straighten out the moment curve below the stall, as in the case of the end plate. In order to obtain stability at the stall, however, a tip-slot is provided to increase the stalling angle of the tip sections. These effects are illustrated in Fig. 10, while Fig. 11 shows that, by raising the trim flap in the outer 25 per cent. span and lowering the main flap in the inner 35 per cent. span, the stability characteristics are affected noticeably, presumably because of a decrease in span-wise pressure gradient and therefore in boundary-layer flow.

Recent investigations have indicated that the problem of static longitudinal instability near the stall for plain swept-back wings depends, not only on sweep, but also on aspect ratio, and it now appears that, for a given sweepback, the magnitude of the unstable break in the moment curve decreases with decreasing aspect ratio, eventually vanishing. The possibility of controlling the stalled portions of the wing, as outlined, means that trailing edge flap controls can be laid out to maintain their effectiveness at very high angles of attack. Since a certain portion of this flap must be used to provide high lift and roll control, the amount available for longitudinal trim is limited, so that on the XB-35, for example, the total available nose-up pitching moment coefficient is 0·15 as compared with 0·30 for a conventional aeroplane. This limited control, together with the fact that the main wing flaps apparently cannot be made self-trimming and impose a diving moment in the landing condition, reduces the available centre of gravity range in percentage of the mean aerodynamic chord (m.a.c.) as compared with conventional aeroplanes. The XB-35 has a centre of gravity range of only 5 per cent. or 6 per cent., as compared with conventional values of the order of 10 per cent. or 12 per cent. This comparison, however, is somewhat misleading, because the all-wing aeroplane may have a greater comparative m.a.c. in view of its somewhat lighter wing loading. It is also much easier to arrange weight empty and useful load items span-wise within close m.a.c. limits than in conventional types.

Where manual control of the elevator is employed, the stick-free stability and control of all-wing aircraft are impaired by separation of the flow from the upper surface of the wing near the trailing edge, causing up-floating tendencies at higher lift coefficients. If not corrected, these up-floating tendencies lead to stick-free instability and, in some cases, to serious control-force reversal at high lift coefficient. Aerodynamic design refinements devised and tested by us up to the present have not provided a satisfactory solution to the up-floating tendency. For small aeroplanes these undesirable forces can sometimes be tolerated, but for large aircraft the only solution found so far has been the employment of irreversible full power-driven control surfaces.

It is when considering the lateral stability and control factors that the difference between the all-wing and conventional aeroplanes becomes most apparent. The swept-back wing has inherent directional stability which increases with increasing lift coefficient; but this is not considered sufficient for satisfactory flight characteristics in all circumstances, and must be supplemented by some additional device. The wing-tip fin has been favoured by some since it gives the largest yawing lever arm and provides a suitable rudder location. However, as previously pointed out, wing-tip fins may be unsatisfactory at the stall. For the X.B.-35 configuration, effective fin area is provided in large measure by the side force derivative of the pusher propellers.

All-wing aeroplanes, particularly those without fins, have a very low cross-wind derivative; thus a

Fig. 8.

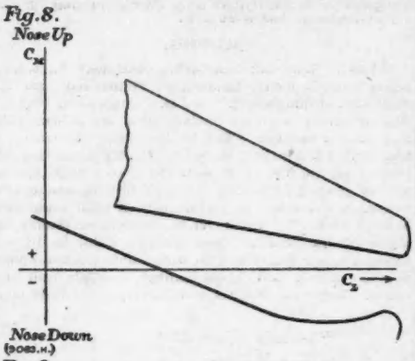


Fig. 9.

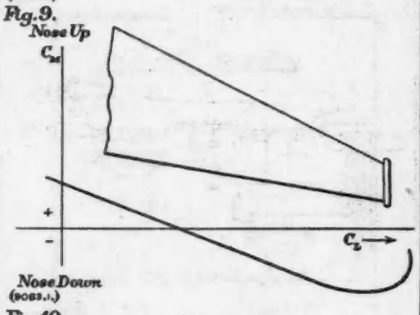


Fig. 10.

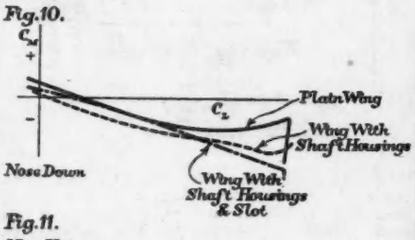
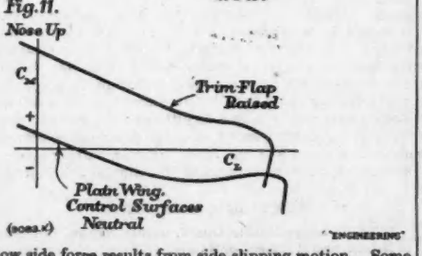


Fig. 11.



low side force results from side-slipping motion. Some cross-wind force is probably important for precision flight, such as tight formation flying, bombing runs, gun-training manœuvres, or pursuit. For the correction of the lack of sideslip sense, a sideslip meter may be provided for the pilot or automatic pilot, and for very long-range aircraft there is a valuable compensating advantage in being able to fly under conditions of asymmetrical power without appreciable increase in drag.

The application of automatic pilot control to an all-wing aeroplane has certain difficulties which are associated primarily with the low value of the side force derivative. In conventional applications the fact that the aeroplane is side slipping is detected either by a lateral acceleration or an angle of bank. In an all-wing aeroplane, neither of these indications exists except in an almost undetectable amount. Accordingly, in order to fly the aeroplane at zero sideslip, and therefore in the direction of its centre line, it is necessary to provide a yaw-vane signal to which the pilot or automatic pilot will respond. This introduces some difficulty in automatic-pilot design because, for small disturbances, the sideslip angle with respect to the wind, and the yaw angle with respect to a set of fixed axes, are nearly equal and opposite for a flying wing. The customary automatic-pilot control on azimuth angle therefore tends to oppose the necessary control on sideslip. To avoid this difficulty it is necessary only to reduce the rate of control on sideslip to approximately one-third that on azimuth. This modification to a conventional automatic pilot was flown on the N9M with complete success.

Based on a great many studies of various types and applications of the all-wing principle, some practical limitations may be defined approximately. Where payloads of a high specific gravity are contemplated, such as warheads or similar munitions, quite small units are practical, as demonstrated by the all-wing flying bombs to which reference has been made. Medium-sized units having a span of perhaps 100 ft. and a gross weight of 50,000 lb. to 60,000 lb., appear entirely practical for medium bombers and freighters. Here again the density of the useful load, both in payload and fuel, is comparatively high. Aeroplanes designed to carry people need the largest volume of all. Even individual reclining chair accommodations require a minimum space of perhaps 40 cub. ft. for each passenger, which is equivalent to a density of approximately 5 lb. per cubic foot. This is one-half to one-quarter the density of typical air cargo, and only 4 or 5 per cent. of the density of a warhead. It may be concluded, therefore, that the all-wing design is immediately applicable and practical for a number of military and cargo-carrying versions, and that the passenger-carrying aircraft are likely to be of rather large size and, in the immediate future at least, will provide only comfortable seating instead of the more luxurious appurtenances associated with long-range ocean travel. An aeroplane of the XB-35 configuration and size can carry 50 passengers in comfort in the existing aerofoil envelope with adequate headroom for all, and with vision forward through the leading edge, downward through windows in the floor, and, if desired, upwards. The same aeroplane will have cargo space for 40,000 lb. to 50,000 lb. of air freight at a density of 10 lb. to 15 lb. per cubic foot, in addition to the necessary crew and space for 50 passengers.

With regard to the future, it seems that considerable further aerodynamic refinement can be made over that already accomplished in all-wing types. The minimum parasite drag may be reduced to 0·008 or less, particularly if turbo-jets are used as the motive power. Boundary-layer removal and the use of somewhat thinner wing sections may reduce this figure further. A maximum trimmed lift coefficient of 1·9 for the all-wing configuration seems attainable by methods already suggested and possibly may be increased further by judicious use of boundary-layer control in combination with turbo-jet power plants. It is our opinion that the ratio of $C_{L_{max.}}$ to $C_{D_{min.}}$ may be increased to a value of 235 within the not-too-distant future from our present actual achievement of about 130. In contrast, the years of intensive development of the conventional types already passed promise an improvement of less magnitude within a comparable time. In our judgment a trimmed maximum lift of 2·8 against a minimum drag of 0·020 seems reasonable to expect for large, long-range transport and bombardment aircraft of conventional type. These estimates, of course, are completely arbitrary and controversial. However, if one assumes their validity, the following conclusions may be reached, based on methods and calculations used in the early part of this lecture. The total minimum profile drag of the all-wing aeroplane in terms of the conventional will be from 40 to 59 per cent. The power required by the all-wing type to maintain the same cruising speed as the conventional will be from 70 to 80 per cent. and, conversely, the maximum range of the all-wing, at the cruising speed of the conventional aeroplane, will be 143 to 125 per cent. The maximum range of the all-wing aeroplane at its best cruising speed will be 158 to 130 per cent. of the conventional and the most economic speed will be from 125 to 115 per cent. faster. Under high-speed conditions corresponding to full power of reciprocating, turbo-propeller or turbo-jet engines, where the induced drag is assumed to be 20 per cent. and the parasite drag 80 per cent. of the total, the power required to drive the all-wing aeroplane at the speed of the conventional aeroplane will be 52 to 67 per cent. and, conversely, the range will be 192 to 149 per cent. of the conventional aeroplane. The maximum speed of the all-wing aeroplane at comparable powers will be 124 to 114 per cent. of its conventional counterpart. Different assumptions of comparative maximum lift and minimum drag values can be made to suit individual opinion, but it is believed that any reasonable assumptions will always result in an advantage to the all-wing configuration of such magnitude

as to warrant the trials and tribulations associated with its development.

So far in this discussion, transonic and supersonic considerations have been avoided purposely. For military aircraft, however, we cannot ignore the sonic "barrier" and its implications, and it is a reasonable assumption that, sooner or later, improved fuels will permit higher and higher operational speeds, even in commercial aircraft. Based on present knowledge of supersonic flight, it will always be more difficult to carry a given payload for a given range at supersonic speed because of the additional wave drag encountered at these speeds. At transonic or comparatively low supersonic speeds, a plain swept-back wing appears to be one of the best possible configurations, provided that sufficient volume is available within the wing. Since the flow normal to the leading edge is subsonic over almost the entire wing surface, subsonic aerofoils with reasonably good subsonic flight characteristics can be used at these speeds. The all-wing design eliminates wing-fuselage interference as well as adverse interference between the tail surfaces and wing or body.

At higher supersonic speeds, however, the problem of providing adequate volume is more difficult because more and more fuel is required for a given range and the percentage of thickness of aerofoils suitable for such use is much less than that satisfactory for subsonic flight. Save for one compensating factor, this problem of volume and size might well rule out the all-wing aeroplane for supersonic use, and certainly does limit its usefulness for low-altitude flight. However, an attractive field of operation exists at very high altitude where air densities are low and therefore, wing areas must be comparably greater if suitable lift coefficients are to be maintained. If a sufficiently high altitude is chosen it seems quite possible that adequate volume can be secured in the wing, in spite of its small thickness ratio, by using low aspect ratio plan-forms approaching the triangular.

The comparative data for two wings having the same physical depth at the root, and identical wing areas are given in Table I, below. The conventional

TABLE I.

Type.	Conventional.	Delta.
Thickness at root	1	1
Taper ratio	2 : 1	∞
Thickness ratio	15 per cent.	7½ per cent.
Aspect ratio	8	4·5
Root-chord ratio	1	2
Span ratio	1	0·75
Volume ratio	1	0·833

wing is of a type already proved practical for all-wing aeroplanes. The delta wing has thickness ratios suitable for supersonic flight, identical thickness, and only slightly reduced volume. It should be quite suitable for all-wing aircraft of reasonable size. From the aerodynamic point of view it appears that, with the delta wing, it is possible to eliminate a substantial portion of the wave resistance and thus realise fairly favourable lift-drag ratios at supersonic speeds.

It is gratifying to those of us who have been working on all-wing projects for years to recognise the increased interest in the type evidenced in Germany towards the end of the war, and more particularly in England and Canada in recent years. For many years we received scant encouragement and often questioned seriously our own judgment, as well as our ability, to achieve a successful solution to the many problems involved in the development of this type. The goals and rewards have always seemed well worth attainment, however, and I believe accomplishments to date have justified the effort required.

FRENCH SOCIETY OF AUTOMOBILE ENGINEERS.—In connection with the 20th anniversary of the foundation of the Société des Ingénieurs de l'Automobile, an international congress is to be held in Paris, from October 10 to 12. An exhibition on the history of the motor car will also be held at the Conservatoire des Arts et Métiers from October 3 to 12, and, on October 12, visits will be paid to the laboratories of the Centre Technique de l'Automobile and to the "Autodrome" at Montlhéry. Further particulars may be obtained from the secretary of the Société, 5, Avenue de Friedland, Paris, 8e.

100-KW SHORT-WAVE TRANSMITTERS FOR SWEDEN.—Two 100-kW short-wave broadcasting transmitters are to be constructed by Marconi's Wireless Telegraph Company, Limited, Chelmsford, for the Swedish broadcasting station at Hörby. These transmitters which, it is stated, will be among the most powerful of their type in the world, will be used to augment the existing medium-wave broadcasting service. It is understood that one will be employed for "omni-directional" broadcasting and that the second will be connected to a special aerial system, so that the signals can be "beamed" in one of several directions.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

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Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

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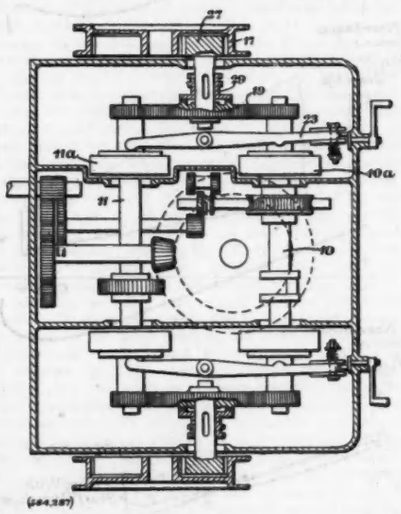
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MINING.

584,287. Shortwall Coal-Cutting Machine. Anderson, Boyes and Company, Limited, of Motherwell, and A. Anderson, of Motherwell. (1 *Fig.*) August 26, 1944.—The invention provides haulage gear for a shortwall coal-cutting machine. The haulage gear consists of a first shaft 10, a second shaft 11, variable-speed gearing connecting the first shaft with the second shaft, transmission gearing connecting the shaft 10 with a source of power, two clutches 10*a*, 11*a*, on each shaft, and two haulage drums 17, which can be clutched selectively to either of the shafts. Each haulage drum is driven through a spur gear wheel 19, with which meshes a pair of gear pinions, each driven through a clutch from the shafts. The two clutches can be engaged selectively,



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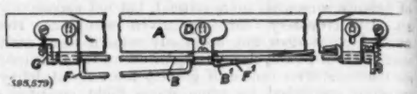
but not simultaneously, by a lever 23 and a crank handle which acts on the lever through a yieldable spring. Each drum 17 has internal teeth engaged by a gear pinion 27 which rotates with the spur gear wheel 19. A clutch 29 is provided so that the drum may rotate freely. When the clutch 10*a* on the shaft 10 is engaged, the drum 17 is driven at flitting speed. When the clutch 11*a* on the shaft 11 is engaged, the drum 17 is driven at the cutting speed fixed by the variable-speed gearing. Both drums can be driven at flitting speed, or both can be driven at cutting speed, or either drum can be driven at flitting speed and the other drum at cutting speed, merely by selective control of the clutches. (*Sealed.*)

TEXTILE MACHINERY

585,579. Loom-Shuttle Guard. James Nelson, Limited, of Nelson, and S. Brown, of Nelson. (4 *Figs.*) November 4, 1944.—The guard normally occupies an operative position, and can be pushed back by the weaver to an inoperative position against the action of a spring, and will automatically return to its operative position by the momentum of the sley when the loom is set in motion. This construction reduces the effort required to turn the guard back and enables it to yield more readily when passing over an operative's hand in the event of the latter being on the loom temple when the sley comes forward. The shuttle guard consists of a rear rod made in two lengths B B^1 which are pivoted in two end brackets and a centre bracket D, and a front rod. The brackets are fixed to the front of the hand rail A and are slotted for vertical adjustment. The centre bracket has a removable cap to facilitate assembly and removal of the guard. The ends of the two front rod portions F F^1 are cranked and brazed to the rear rod portions. The cranking is such that each front rod portion occupies an inclined position when the guard is in its operative position. The rear rod guards the intervening space between the front rod and the hand rail. The outer end of each rear rod portion B B^1 projects through the end bracket and has fixed on it a short crank arm G with a projecting crank-pin that is attached by a spring to the bracket. This spring normally maintains the cranked portion of the guard in contact with a stop on the bracket and the



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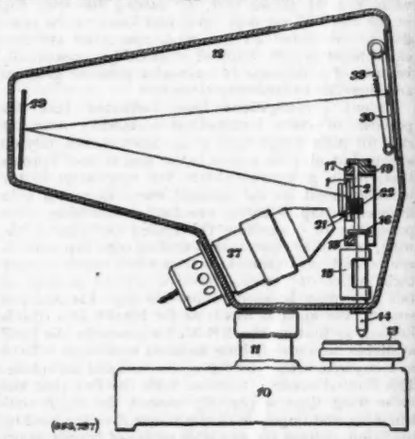
stop retains the guard in its operative position. To move either guard portion to its inoperative position, the corresponding front rod portion is pressed back until the cranked portion at its inner end abuts against a stop on the centre bracket D. In this position the crank-pin has moved slightly past the dead centre, and the spring retains the guard in its inoperative position. When the loom is set in motion the guard returns automatically to its operative position. (*Accepted February* 12, 1947.)

MISCELLANEOUS.

585,787. Optical Measuring Instrument. The Sigma Instrument Company, Limited, of Letchworth, J. Loxham, of Letchworth, and H. Emsley, of London. (7 *Figs.*) May 5, 1941.—The invention is an optical instrument by which small gauging movements are accurately converted into larger angular deflections of an indicating beam. A base 10 carries a pillar 11 supporting a body 12 which is adjustable vertically. A fixed anvil 13 secured to the base 10 acts as the reference anvil of the instrument. A movable gauging anvil 14 projects from the lower side of the body 12. The anvil 14 slides in a bracket 15, and at its upper end has a head 16. The latter enters a ring 17 and makes contact with a pin 18 secured thereto, the ring 17 being urged upwardly by a spring. The ring 17 lies against a U-shaped bracket 19 which is secured to the body 12 of the instrument. An abutment projects laterally from the U-brackets 19 and limits the upward movement of the ring 17. A blade spring 21 is secured at each end to the ring 17 so that the blade lies along the horizontal diameter of the ring. A similar blade spring 22 is secured to the U-bracket 19, and lies adjacent to the blade 21. At about their centres a block lies between the two blades and a clamping member sandwiches the block and blades and supports a mirror 2. When the



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anvil 14 is moved up, the head 16 is similarly moved and allows the ring 17 to move up under the action of the spring so that the blades 21 and 22 are distorted and the mirror 2 is turned about a horizontal axis. A mirror 1 is fixed to a bracket which is attached to the body of the instrument. An electric lamp supplies a beam to a condenser in a tube 27. There is a graticule inside the tube and the emergent beam is projected upon a fixed mirror 29 which reflects the beam on to a screen 30. The image formed on the screen due to the graticule, is that of a scale. The scale moves up and down when the mirror 2 swings about its horizontal axis. A pointer is carried upon a band 33 passing over a pair of pulleys. A spring ensures that adequate tension is maintained in the band 33 and a knob permits the band to be displaced to adjust the position of the pointer. In use, a nominally correct distance piece is placed between the anvils 13 and 14, the body 12 being adjusted up the pillar 11 if necessary. When the anvil 14 is engaging the piece, the scale is brought to a particular position and the pointer set. The distance piece is removed and further pieces for comparison are inserted between the anvils 13 and 14. The scale will be displaced from the correct setting of the pointer if the pieces do not correspond in size to the correct piece. (*Accepted February* 25, 1947.)